Popular Astronomy.

Vol. XXVIII, No. 3 MARCH, 1920. Whole No. 273

MARS OUR NEIGHBOR IN SPACE.

By GEORGE HALL HAMILTON.

Of all the planets that revolve in nearly circular orbits around the Sun, the planet Mars is the most interesting. The chief reason for this is because of its nearness to our Earth, it being the next planet outward. Among its many interesting characteristics, its similarity to our Earth predominates; this, as far as our knowledge of the Solar System extends, is greater in Mars than in any of the other planets.

It will be seen therefore, that there is a globe wending its way in space, like unto our Earth; a voyager of the skies which we can view with the aid of the telescope just as a very distant ship on the ocean can be viewed from the deck of another.

The opposition or near approach of the planet is the best and in fact the only time that we may study it; at this time the Earth, as it revolves around the Sun, catches up to Mars; Mars, having farther to go in its path around the Sun, takes 687 of our days to make one revolution, that is, its year is 687 days long. As our year is composed of 365 days, the Earth passes between Mars and the Sun every two years and a little over a month, and during a period of six months Mars is then near enough to be viewed and drawn to advantage.

During the time of near approach one can see the whole surface of Mars very well indeed. With a telescope such as the one at the Lowell Observatory, the planet is enlarged so that it is from four to five times greater in diameter than the moon looks to the naked eye.

The planet revolves on its axis in about forty minutes longer time than the Earth, that is, it has a day forty minutes longer than our own, and as the disk is viewed in the telescope we are able to see it slowly revolve before our eyes, thus presenting every portion of its surface in turn to our view.

This surface shows itself in color, large regions having the same tints as our own deserts viewed from a distance, a reddish-ochre hue; while others show as dark markings of a decided dark blue-green.

Depending on what part of its orbit the planet is in at opposition, and due to the tilt of its axis to its orbit, the planet may show either the North Pole, the Souh Pole, or both. Whichever one we see shows up intensely bright, as our own snow-covered polar caps would look from a distance.

Beside these markings many more are seen covering the disk both in the desert regions and the dark areas; these impress themselves on our eye as fine lines and small dots, called by Lowell and others "canals" and "oases". Again in the deserts we are able to see small white patches, but less white than the polar caps, dotted about seemingly at random, though always remaining in the same place on the planet.

I am illustrating this article with three of my drawings taken at last opposition, that of March, 1918. These drawings are those of March 25, April 8 and April 23.

That of April 8 shows more detail in the desert regions (the light areas) than anywhere else, and gives one a good impression of the "canals". In the center of this drawing one sees the "Pentagon" or as it is otherwise known "Elysium".

This is a rough five-sided figure, as its first name implies. In it one is able to see the tiny oasis the Fons Immortalis with two very fine canals branching out from it. To the right of this figure and below it one sees the Wedge of Casius, a broad and dark wedge-shaped formation surmounted by a rather large oasis and the curved and double canal, the Thoth. The North Polar Cap is the circular white patch at the bottom—the astronomical telescope inverts the object looked at and thus the northern regions of Mars are at the bottom of the drawing.

It will be noticed that the canals interlock and form a network over the surface of the planet and that they are nearly all straight lines, or correctly speaking great circles; that is, the shortest distance between points on a sphere.

It is obvious at a glance that we have no such markings on the Earth. But if we were to increase our irrigation system through our deserts beyond all proportion to what we have already done, and vegetation should grow luxuriantly miles in breadth along the banks of these water courses, we might approximate to what we see on Mars. The fact that the earth in a natural state shows no such features is one of the main reasons for believing that what we see on Mars is a vast artificial network, covering the planet; and as these markings wax and wane with the seasons, which follow each other on Mars as on the Earth, it presupposes a connection between these markings and the vegetal growth on the planet. I will show that we have further proof that this may be the case.

The drawing of March 25 will help to explain this. It will be noted

in this drawing that the north polar cap has a definite dark band surrounding it; this band moves on the planet's surface, following the decreasing cap as it melts during the summer. The band is of a dark blue color and reminds one forcibly of water left by melting snows; this we believe is what it is. It will be further noticed that many of the canals are actually connected up with this band of water surrounding the melting cap.

At this point it will be well to have in mind that, owing to Mars being much smaller than the Earth—about 4200 miles in diameter, while the Earth is nearly 8000 miles—the atmosphere on Mars is much less dense than that on the Earth, and precludes the possibility of rainfall, such as we have on Earth, no clouds being visible on the daylight side of Mars. This does not seem to stop vegetational growth, however.

As the summer advances on Mars, the canals and dark areas increase in intensity. This synchronizes with the melting of the polar cap, the canals becoming darker near the pole as it begins to melt in the spring, and gradually increasing in intensity towards the equator during the following months. It has been found that some fifty-two days after the cap starts to melt, the canals have darkened right up to the equator. This then seems to prove that verdure grows on Mars during the summer as it does on Earth, but that for its growth it is dependent upon the polar cap or caps, taking into account both hemispheres, for water. If this is so, there must indeed be a vast irrigation system on Mars.

Admitting this, in what manner might it be done? And would we be able to see evidence of it through the telescope? In the first place, if it were necessary for intelligent beings on a globe to acquire their water for agricultural purposes from the polar snows, the most economical mode of transportation would, at some time or another, be found; and this would in a large measure depend on the contour of the globe's surface. If there were large mountain ranges, there might be insuperable difficulties or else these difficulties would have to be overcome by hydraulic machinery, etc., at enormous cost. Now if there were mountains on Mars comparable at all with those of the Earth, the telescope would surely show them; but we find no signs of any—to all intents it is a level globe. This is what we might expect from a world of this size, and being level, in the sense of smoothness, water would rest upon its surface without motion from place to place; as in a globe left to itself its surface attains stable equilibrium, and the force of gravity acts perpendicularly to its surface at every point.

Under these conditions water could not flow of itself from the poles to the equator, for the globe would already have adjusted itself to its rotation on its axis, and the centrifugal force generated could not carry the water away from the poles.

For any mountain to give the water sufficient fall to reach the equator it would have to be as large or larger than any on the Earth. This

we know cannot be, for we would be able to see it; therefore some mechanical means must be used to bring the waters from the poles.

Whatever may be used, we would at once expect the water to be carried from point to point along the shortest route, as there are no intervening mountains. From the nature of the case one would expect this, and our supposition is amply justified from the canal-like markings seen on the drawings, which are typical of all the drawings made by Lowell over a period of more than twenty years.

It is seen therefore that a globe like Mars might, if inhabited, need an irrigation system of vast proportions to support life, and such a system has been shown feasible, providing that the beings who inhabited it were sufficiently advanced to undertake such a project. Not only that, but the drawings of Mars show markings which support this theory in all respects.

From Venus for instance (the planet next to our Earth towards the Sun) the Earth would be seen in a similar manner; but the fact that life existed upon it could no more be detected in its case than it can be upon Mars. The fact that life existed might be suspected, but it could only be so from surface markings such as large tracts of vegetation waxing and waning with the change of season, and then only where vegetation was seen to grow in places where it would not otherwise be expected, unless under cultivation. We know that this occurs on Earth, but whether in large enough tracts to be visible so far out in space is very doubtful.

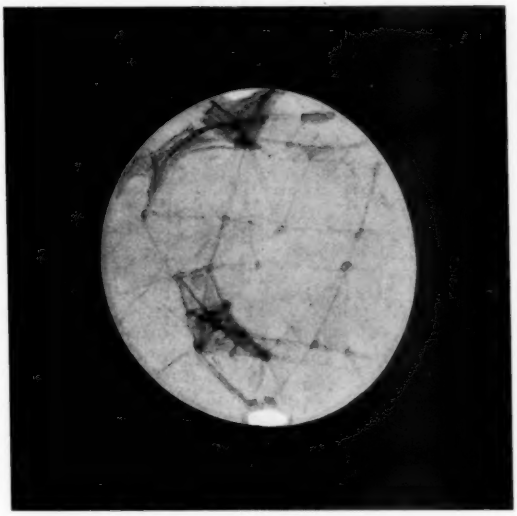
If it were possible that climatic conditions on Mars, as well as its topography, would warrant the placing of large areas under intensive cultivation, it would be extremely probably that they might be seen from the Earth. This is seemingly the case; for we have every reason to believe that what we see on the surface of Mars shows definite proofs of artificiality. This will be evident from the drawings.

If it seems an extravagant supposition, it need only be said that during the period of Mars' history it has in all probability passed through cycles of change corresponding to that which we know of on the Earth. The dark areas which now support vegetation are evidently old sea bottoms and during the gradual disappearance of the seas, intelligent life would have had ample opportunity to develop a water system of this magnitude.

Mars is an old world, with a probable civilization of great age, and the law of Earth, a law of all nature, survival under difficulties.

Lowell Observatory, Flagstaff, Arizona.

PLATE VIII



April 23, 1918, 8^h 00^m
$\lambda = 58°$ Seeing 6

DRAWING OF MARS MADE AT THE LOWELL OBSERVATORY
BY G. H. HAMILTON.

OCCULTATION OF JUPITER'S SATELLITE I
BY SATELLITE III,
Observed by G. H. Hamilton, Lowell
Observatory, Flagstaff, Arizona.

OCCULTATION OF SATELLITE I BY SATELLITE III, IN THE JOVIAN SYSTEM.

By GEORGE HALL HAMILTON.

While working at the 24-inch telescope on the night of December 5 —I have been studying the transits of the satellites of Jupiter—my attention was drawn to two of the satellites. They were following each other closely as they approached the planet preparatory to crossing the disk. For some time I saw no appreciable difference in their motion, and though I knew that they were the satellites Io (I) and Ganymede (III), I had not examined them thoroughly enough to differentiate them, but on seeing the following one gradually increase in speed and close up on the other, I realized that Io was going to pass Ganymede.

I then remembered that we were nearly in the plane of Jupiter's equator, that the satellites would pass very close to each other, and that there might be a possibility of an occultation. I stopped my drawing of Jupiter and paid close attention to the two moons; I was well rewarded; Io gradually approached Ganymede till it was evident that it would pass under it. I had not expected to use the micrometer and I found that it was not adjusted, so had to rely upon sight alone for what followed.

The middle of the occultation, which I believe was complete, occurred at or about $17^h\ 00^m\ 45^s$ M.M.T. I could not get first contact, so took the mean time of two estimated elongations before and after complete disappearance. While this phenomenon was in progress I began to wonder what I might be able to make out from the study of such an occurrence, and as the seeing was improving all the time, I had great hopes of viewing something of interest.

As the satellite Io entered behind I saw nothing in particular but the seeming elongation of a single satellite, and it gave one the impression of being very large; then, as it went completely under, Ganymede resumed its wonted size, except that I thought I dimly saw satellite I grazing along the southern limb of III.

By the time that Io made its reappearance on the limb of Ganymede, the seeing was almost perfect and what was my astonishment to see a dark dividing line where the limb of III was projected on I. I studied it and found it real; it was a continuous feature until fourth contact. I am certain now, and was then, that what I saw was the phase of III, projected upon the bright disk of I. The brilliancy of the two satellites was not equal; the large satellite III was quite dark against the disk of the small one, and seemed of a greenish hue when compared with the other, which was seemingly quite yellow.

As a rule the satellites all present such small disks that it is almost impossible to make anything out of them, but I noticed a curious effect

at this time, for the disk composed of the two satellites was quite appreciable in size, and I am certain that the larger area thus presented, enabled me to appreciate much detail that I would not otherwise have seen. Besides the division between the two satellites, which persisted from time of third contact to fourth, and which I took to be the phase on III, I was able to see the complete disks very well, not only estimating their relative sizes, which I took to be 7 and 12, but also seeing detail on the disk of III.

It seemingly has a northern polar cap or patch; it was quite pronounced and persistent and I was able to estimate its brightness with respect to satellite I. I found it to be as bright as this satellite. There was also a bright but dimmer region at the south, more elongated east and west but not as deep as the patch at the north. This southern marking was visible even though it was close to the bright satellite coming out from occultation.

It may be argued that what I took to be the phase of Ganymede on the disk of Io, was nothing more than the geometrical falling off in brightness towards the limb; this would account for the increased visibility of the phase, it is true, giving it a slightly greater breadth, as would also a slight atmosphere if the third satellite chanced to have one. I feel certain though that the phase predominated.

Whatever it may be, the observation has made me feel certain that the limb radiation on III was completely cut down, and future observations with the micrometer may therefore tell with greater accuracy the diameter of the disk, as the diameter should read smaller than a direct measure with sky as background, by half the total radiation or the depth that the radiation extends beyond the disk.

These observations are necessarily few and far between, as the period during which one may observe them can only occur twice in Jupiter's revolution in its orbit, or every six years, and then only if Jupiter is distant enough from the Sun to be observed to advantage.*

This occultation occurred at approximately 0^h G.M.T. December 6, and the Jovicentric declination of the Earth was 0°.00 on December 4, 1919.

On December 6, at 19^h, I observed the commencement of the occultation of Europa by Ganymede. This lasted from $19^h\ 01^m\ 48^s$ to $19^h\ 11^m\ 58^s$ G.M.T. The seeing was very bad on account of a severe storm which was approaching, so that there is probably considerable error in the observed period of occultation. The time of complete submergence was necessarily short, as the two satellites were passing each other at the time, instead of moving in the same direction as in my first observation.

I find that the first is of rare occurrence as it is not often that the

* At these times, owing to the motions of the Earth and Jupiter, the Earth passes several times over Jupiter's equator.

satellites will overtake each other as they pass across the field of view; and it is obvious that this is the most favorable position in which to observe them.

Many interesting possibilities will occur to the reader as the outcome of such observations; and they therefore should be pushed with all vigor, during the few days when the Earth is on Jupiter's equator. It must also be noted that there are very few satellite conjunctions observable at those times.

Lowell Observatory, Flagstaff, Arizona.

FIRST STUDY OF HEAVENLY BODIES.

By MARY E. BYRD.

Lesson III.

Since the first of these lessons appeared with a somewhat agnostic view of present-day students, there have come from a Wisconsin farm, a fort in Colorado, and a convent in Indiana reports from genuine students. Their tribe may have grown smaller. It certainly is not extinct. At least a remnant is left of whom it may be said as of Homer's heroes of old, they still live and look upon the earth, aye, and on the heavens too! Their observations include sketches of constellations, positions of the moon among the stars, and a bold attack upon the problem of identifying Mars.

But in the month of March, first and foremost the sun demands attention. The day when it crosses the celestial equator brings favoring conditions for several observations. East and west points are then found simply by watching sunrise and sunset and fixing the places noted by permanent landmarks in the distance. The line joining these cardinal points is of course the prime vertical and the perpendicular to that, the meridian. East and west points, prime vertical and meridian; they sound good, there is only one little difficulty; we must reckon with the skies of March, and not often are they kind enough to give a clear horizon both morning and evening. The location of the sun's diurnal path for the day may be undertaken with more hope of success, and this path is of especial interest, not only because it occupies a mean position between the paths that are low in winter and those that run high in summer, but because it marks out the course of the celestial equator in the heavens; for throughout the day the sun deviates but little from this circle.

As befits its importance, latitude is mentioned last. There are several reasons why its determination by beginners is made most satisfactorily on the day of an equinox, for then practically no calculations are required, no data need be taken from the Ephemeris or any other

authority, it is only necessary to find as accurately as possible the sun's altitude at apparent noon. Its complement is the zenith distance of the sun and that is the latitude of the place. The latter statement requires some explanation. According to Young, latitude may be defined as the declination of the zenith (Art. 47). Note also that at either equinox the sun at noon is practically at the intersection of the celestial equator and meridian and that the meridian is an hour-circle. So at this time the sun's zenith distance is the number of degrees between the equator and the zenith, measured along the hour-circle passing through the latter. But that by definition is the declination of the zenith, i. e., the latitude required.

Before taking up the observations of the moon already mentioned, it is essential to know a little more about star-maps. They are the guides upon which we must depend in all efforts to explore that other world, above the horizon line, nor does it take long for any earnest worker to learn to appreciate real maps. A common experience, I fancy, is that related by a correspondence student who had known only the pretty, pictorial kind, that is about as devoid of definite data and reference circles as that wonderful blank chart, carried by the seamen who went hunting the snark. "When I first got Young's maps," he said, "they puzzled me, but I studied them a little and a great light came. I saw how to use them."

Let us turn, then, for a few minutes to Map IV of Young's Uranography. First, one point not mentioned here must be kept in mind, that, while north is as usual at the top of the page, east is to the left, not on the right as in geographical maps. The two fundamental reference circles of astronomy we find marked by conspicuous dark lines. the straight one through the middle of the page representing a section of the celestial equator, and the curved line inclined to it, a part of the ecliptic. The point where they intersect fixes the vernal equinox, the zero for both circles.

The ecliptic is of interest because it shows the apparent path of the sun in the heavens, and those who go on with astronomical study often have occasion to use it; but it is the celestial equator that is of prime importance. Speaking as of the earth, earthy, no celestial body gains recognition until its position is known, at least approximately, in reference to this circle. The two measures required in making the location correspond to longitude and latitude on the earth but they have different names. Thus, the eastward measurement along the equator is called right ascension, and that to the north or south, declination. To aid in making measures two sets of auxiliary lines are employed, those parallel to the equator being named parallels of declination and those perpendicular, hour-circles. There may be an unlimited number in either set. On the map considered there are eight hour-circles, separated from each other by just one hour and designated on the equator

by Roman numerals which show by how many hours of right ascension each lies east of the vernal equinox. There are also eight parallels of declination, four north and four south of the equator, placed 10 degrees from the equator and from each other. If then, a celestial object is on one of these hour-circles or parallels, its right ascension or declination is read off directly, and a practical illustration, showing how to find these coördinates for objects between the reference circles, is given in the discussion of lunar positions, and that is our next topic.

Including those obtained in Colorado and Wisconsin, there are six observed positions of the moon. (Speak softly, lest the mathematical astronomers hear us talking of combining lunar observations, made hundreds of miles apart, with no word of parallax or any other correction!). They are well distributed over a period of two weeks, and the problem is to make them yield every possible bit of information about this part of one of the moon's monthly trips through the zodiac. In order to save space in the tabular outline, it may be said that the observations of Nov. 29 and Dec. 6 were made at Fort Lyon, Colorado and the others at Fall River, Wisconsin. For the same reason the day of the week, which should always be included in the original record, is omitted here. Other needed data are given below in the following table:

TABLE I.

POSITIONS OF MOON BY EYE-ESTIMATE, NOV.-DEC., 1919.

Date.	Position.	Observer.
Nov. 29, 5.8, P. M.	In line with θ Pegasi and α Aquarii and equally distant from α and β Aquarii.	W. V. C.
Dec. 1, 8.5, P. M.	In line with γ and λ Piscium, midway between them.	A. L. P.
Dec. 4, 9.0, P. M.	At end of extended line α Triang. - α Arietis, prolonged its own length below the latter.	A. L. P
Dec. 6, 8.0, P. M.	In line with ι Aurigae and α Tauri, ¼ distance between them from α Tauri.	W. V. C.
Dec. 10, 10.5, P. M.	Directly below Praesepe, a distance equal to that between α and β Urs. Maj., i. e., 5°.	A. L. P.
Dec. 14, 1.5, A. M.	At end of extended line δ θ Leonis, prolonged four times itself below θ.	A. L. P.

The ideal way of dealing with observations like these is to plot them on a celestial globe, and the next best appliance is an accurate star-map of large size. However, Young's Uranography, though on so small a scale that, using the same plotting paper, one can hardly obtain the same results on different days, serves, nevertheless, to bring out the salient points.

Let us locate the first position, then, on Map IV, by prolonging, as directed, the star-line θ Pegasi-α Aquarii, and finding the point on it that is equally distant from both α and β Aquarii. It is fixed a little west of the hour-circle XXII and above the 10°-parallel of south declination. To obtain exact coördinates, we find by measuring with a strip of plotting paper that the point fixed is $0.7d$ west of the hour-

circle and 3.2*d* north of the parallel, also that the space between the hour-circles XXI and XXII equals 14.0*d* and the 10°-space from equator to parallel, 11.8*d*, where *d* is one division of the paper used. So right ascension is $22^h - 0.7/14.0$ of 60^m, or $21^h\ 57^m$, and declination $-10° + 3.2/11.8$ of 10°, that is −7°.3, values that differ from the Ephemeris check, respectively, by about a minute and a third of a degree, variations, perhaps, no larger than would be expected with the method employed.

With all the six dots for the moon placed in this way, we have, craving pardon for a pleasurable bit of exaggeration, riches of knowledge within reach. As the pages of the uranography are turned, and the dots followed from map to map, the most striking fact is the rapidity with which the moon is moving eastward among the stars. Its path is easy to follow as it keeps close to the ecliptic, and along the way features of interest are not lacking. In Aquarius it reaches the point in declination farthest south, −7°; in Taurus attains its highest northern declination, +20°; when not far from red Aldebaran it is in perigee (O. F. Almanac, p. 29); in the vicinity of the pentagon in Pisces it makes its closest approach to the vernal equinox; and near the eastward boundary of Aries it crosses the ecliptic going south.

Nor is the limit yet reached to what the six points can give. If the space separating the two positions on Map IV is evaluated in degrees along the ecliptic and divided by the interval between them in days, the result, 11°.1, is one value for the moon's daily rate of motion; another and much larger value, 17°.5, is derived from the third and fourth observations, and though the two differ from their mean, 14°.3, more than is desirable, that does not look bad when compared with the standard, daily rate, 13°.2, given in the text-books and of course dependent on many critical determinations.

In discussing observations like these, it is necessary to guard against two false notions. The moon cannot really come near the stars; they are immensely far away, and it, comparatively speaking, is within hand-reach. Neither does its path on the celestial sphere, important though it be, lead to determining the moon's real orbit in space. That is a problem beyond the unaided eye. But these cautions by no means imply any criticism of the method employed. To deal with celestial bodies as they appear to us, projected on the background of the stars, is the approved method in astronomy. We must simply remember that here, as often, things are not as they seem.

It is, however, high time to turn from the moon. Mars awaits attention, and neither in mythology nor astronomy is it associated with patient waiting. The account of the identification of the "red planet" which follows is somewhat abridged from the original notes, but pains have been taken to keep the substance unchanged:

"In placing the planets I use times from Dr. Jayne's Almanac.

"Jupiter, which rises about 6.5 P. M. on Jan. 11, will be setting about the same time on the following morning, and Saturn, rising 2 hours later, will be well past the meridian. As Venus on the 12th does not rise till after 4 A. M., at 6 it is well up. Mars being a morning star, rising about 12.5 A. M., is best observed in the morning. My first observation follows:

"Lone Elm Ast. Station, Fall River, Wis., Monday, Jan. 12, 1920.—At 6 A. M., C.S.T., I find the planet Jupiter is setting and Saturn about midway between the meridian and the western horizon. In the east a bright star-like object is shining which must be Venus because of its very brightness. Near the meridian and south of the equator I find a conspicuous object which must be Mars, as there is no star corresponding to it on the star-maps. I locate this object in line with α ζ Virginis and midway between them.

"At the same place and at 6 A. M. on Jan. 19, a second observation is made. Venus and Saturn are found approximately in the same positions as a week earlier. The object thought to be Mars has moved slightly toward the east, and I now locate it on the star-line θ κ Virginis, 1/3 of the distance between these stars from θ."

A. L. P.

The two positions fixed by star-lines clearly show motion for the suspected planet and the final conclusion that it is Mars carries with it a good degree of assurance, which becomes certainty when the Ephemeris is consulted. For the coördinates given there for this planet on January 12 and 19 are in close agreement with those obtained from the observations described.

Mars is this year the beginner's planet. More favorably placed than Venus, the lengthening days will not blot out its reference stars, when observed in the evening, and its motion compared with that of Jupiter or Saturn is so rapid that its course from one constellation to another is naturally watched with no little interest.

Certainly the planet Mars is entitled to a place in the following list of topics, nor is this its last appearance:

LESSON III.

1. Learn the names and learn how to make the symbols of the Greek letters from ρ to ω inclusive.

2. Define poles of the celestial sphere, parallels of declination, hour-circles, cardinal points, hour-angle, equinoxes, solstices, terrestrial latitude, celestial latitude and longitude, obliquity of the ecliptic, perigee, apogee, and nodes of the moon's orbit. Young's Elements, Arts. 26, 28, 29, 30, 32, 34, 113, 47, 38, 112, 145, 142.

3. As near the spring equinox as possible determine a diurnal path of the sun, using some mechanical appliance in finding altitude and azimuth.

4. *a.* On the day of the equinox find the latitude of the place from the sun's noon altitude.

b. On this day locate the east or west point on the horizon by observing sunrise or sunset.

5. Using Young's Uranography, plot the positions for the moon given in Table I.

6. During the period of observation in what direction was the moon moving among the stars? How was its path placed in reference to the ecliptic? Through what zodiacal constellations did the moon pass? Over how many hours of right ascension? What was its least and what its greatest declination? Where did it make its nearest approach to the vernal equinox? In what constellation was it found when in perigee? Where, approximately, did it cross the ecliptic?

7. Derive values for the moon's daily rate of motion from the first and second, and from the third and fourth observations of Table I.

8. During March note in what constellation and in what part of it Mars is found, and fix carefully one or more positions in reference to neighboring stars.

9. Examine the Pleiades and the nebula in Orion, comparing them as seen with opera-glasses and with the unaided eye.

10. *a*. Review the zodiacal constellations, already known, and add to the number, so as to include the six or seven, visible at convenient hours.

b. Review all known constellations as far as possible and identify four new ones.

It will be a pleasure to receive questions or suggestions in reference to the lessons.

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ON THE SOLAR RADIATION.

By JASON J. NASSAU.*

The determination of the duration of solar radiation presents a number of difficulties and conflicting theories. The two fields of contradiction are based upon the results of gravitational theory on the one hand, and geological and astronomical observations on the other.

The disagreement in the time-scale between the two is great—not merely a discrepancy of the two points of view . As a matter of fact the difference is a hundred to one or even more.

Assuming the average radiation of the sum to be two calories per square centimeter per minute, the total emission is $2 \times 4 \times \pi$ (14500,000,000,000)^2 (the diameter of the sun being 14500000 kilometers). And if the sun had no continuous supply of heat, there would have been a marked decrease of the earth's temperature within historical times. Geologists show that the earth has not varied more than a few tens of degrees from the present temperature for probably more than 50 million years. Then, assuming that the sun emitted its present quota

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of radiation during all that interval, scientists are obliged to form a theory of continuous source of supply. Therefore the so-called Helmholtz-Kelvin contraction theory, as a source of solar energy, has been introduced and universally accepted for more than half a century. Several authors have made computations of the quantity of energy which would be available from this source. Their results have generally been based on the assumption that the sun was originally a nebula, filling a sphere whose diameter was that of the orbit of Neptune. It was found that such a nebula, having the mass of the sun, when contracted as a result of gravitation will produce heat, and expand when heat is radiated. This process would have furnished enough energy to supply the present rate of radiation for 18 million years.

But this is not sufficient to meet the long time-scale proposed by the geologists. To explain a greater age it is necessary to find other sources of energy, so the heat of the radio-active transformation was invoked. Such a form of energy implies the assumption that unknown force is causing the breaking up of ordinary elements inside of the sun, which—under enormous pressure and temperature—is producing a new supply of energy. Mr. Jeans has shown that such source of energy must be very small compared with the energy produced by the Kelvin-Helmholtz hypothesis.

Later another hypothesis was introduced, that of a slow process of annihilation of matter,—matter through positive and negative elections annulling one another—a process which will set free an almost inexhaustible source of energy. The defect of such process is that it supplies energy at some fixed rate, contrary to the energy of contraction, which is drawn on as required and automatically replaces the amount radiated. Professor Eddington points out the numerous objections to such a hypothesis and calls our attention to the fact, that a star would soon expand or contract until the rate of radiation would balance the fixed rate of supply.

The foregoing leads to the conclusion that the contraction theory is by far the most powerful source of energy and capable of providing energy of radiation, at its present rate, for about 20 million years. And that the chemical and radio-active sources, with other recognized atomic sources such as infall of meteoric matter and primitive heat are very small and negligible, or they are included in the gravitational theory.

The search for an additional store of energy presents great difficulties and is not at all encouraging; on the other hand arguments are accumulating against the short time-scale, most of which are the geological evidences which in recent years are becoming more convincing. The formation of stratified rocks and the accumulation of salt in the oceans, both of these studied with the greatest care, lead to the conclusion of a long-time scale. The oldest sedimentary rocks appear to be almost 1500 million years old. A far more important evidence in

measuring the earth's age has been introduced by Schuchert from the radio-activity of terrestrial rocks. In any given uranium-bearing mineral the relative proportions of uranium, radium, and helium can be established. The rate of changes that take place being known, the age of the mineral itself can be determined, which is found to be between 800. and 1600 million years.

In addition to the above arguments of a long time-scale which may be viewed as purely geological, the recent developments in stellar astronomy, described by Mr. Shapley in his paper (*Nature*, March 19, 1919) are worthy of consideration. These may be summarized as follows:

(*a*) The diameter of the known galactic system is found to be not less than half a million light-years, and the velocity of stellar bodies not greater than 10^{-4} times the velocity of light,—therefore a single oscillation period of a star is not less than 10^{10} years. On the other hand Mr. Jeans has shown that a single oscillation of a star in the galactic system does not constitute the duration of the life of that star. Therefore the introduction of such a great linear scale in the sidereal universe will necessitate a corresponding increase in time.

(*b*) The difference in distant globular clusters—some of them 200,000 light-years nearer to the earth than others— affords opportunities for study and comparison of the evolution of such stars. Eddington's computations show that the duration of the total giant stage of a star, *if contraction is its only source of energy*, can not exceed 100,000 years; the light from the most distant globular clusters left its source nearly 200,000 years earlier. But the color-luminosity relation, so far as present results show, is identical and no other evidence of difference of age for near and distant clusters has been found; a fact, which proves that contraction is not the only source of energy.

(c) The luminosity-period curve of Cepheid variables is furnishing additional evidence that the gravitational theory accounts for less than a thousandth of the energy radiated from those stars. A seventy-five years' careful study of γ Geminorum, and still longer study of δ Cephei, shows no measurable change in the luminosity period, and since, according to Eddington and Jeans' hypothesis, period varies inversely as the square root of the density and as long as observation proves that there is no change in density or volume, the conclusion is that a far greater time-scale must be introduced.

(*d*) A similar argument may be developed from the study of the period of eclipsing binaries.

(*e*) Also the total developments of our planetary system require a greater time-scale.

The above outline of results of investigation of physical astronomy, suggests the insufficiency of the contraction theory, thus supporting the geological time-scale of the earth, and ratifies the growing belief

that stellar radiation involves sources of energy that are as yet wholly unknown, and that it is necessary to call upon other sources at present unrecognized to explain the vast number of contradictions now existing.

Before concluding, it will be well to call attention to a wholly new point of view, which Mr. Shapley so admirably describes in his paper (*Nature*, March 19, 1919).

In computing the total energy of the heat radiated from the sun, the usual way—followed by almost all writers—was to multiply the amount of heat measured on a unit area on the earth by the total surface of a sphere whose center is the center of the sun and whose radius the earth's mean distance from the sun.

This customary and natural way of computing the total solar energy involves a waste of energy almost unthinkable, and if the assumption be that solar and stellar radiation is not uniformly propagated in all directions, or be that of the solid angle hypothesis, the controversy between the short and the long time-scales is approaching a solution, is leading to an accordance between astronomical and geological observations and gravitational theory. These suggestions, however, not only have found a number of enemies but are introducing new contradictions and are considered by well-informed authorities as highly improbable.

Royal Observatory, Edinburgh, June, 1919.

SPRING.

O'er mountains, dales, comes Spring with dancing feet,
With many a fragrant flower in her hair.
What other season can with her compare?
Her charm, through bounteous giving, is complete!
Her wand she waves o'er barren woods and fields,
And lo! the earth is turned to fairy-land!
Such precious gifts are scattered by her hand,
That none can doubt the magic power she wields!
The birds, returning, choose each building-site;
Through all the day their joyous love-songs ring.
On new-born wings the butterflies up-spring;
Bees sip, in meadows, blossoms pink and white.
Through life she quickens underneath the mold,
What treasures for mankind doth Spring unfold!

——ALICE BERLINGETT.

Norfolk, Virginia, 1920.

THE OVERTHROW OF NEWTON'S THEORY OF GRAVITATION!

By J. G. PORTER.

No doubt many astronomers, like the writer, have received sensational newspaper clippings concerning the supposed observational proof of Einstein's theory of relativity. One of the most astounding of these appeared recently in the *Independent*, where it is calmly announced that "in the history of science the year 1919 is likely to be known not as the year of the overthrow of the German Empire, but as the year of the overthrow of Newton's theory of gravitation." And all because certain British astronomers found a supposed deviation of the light rays passing near the sun of less than two seconds of arc!

Now, of course, astronomers know that even were Einstein's theory proved, the law of gravitation will for all the practical problems of the heavens remain as true as ever, the modifications affecting only the most recondite researches. But I am sure that most astronomers will agree that this so-called proof of the theory of relativity is of very doubtful validity. A ray of light in passing by the sun will necessarily suffer more or less refraction by the coronal matter which we know surrounds the sun to a considerable distance. Moreover it has been shown that light is slightly deflected in passing through a strong magnetic field. Either of these causes will explain the deviation found on the eclipse photographs. It is also well to remember that these plates were taken under circumstances very unfavorable for accurate measures. The unequal heating of the earth's atmosphere in the neighborhood of the moon's shadow would naturally produce abnormal refraction and cause the distortion of the star images.

In any case it is unscientific to assume a new and wholly problematical cause for an effect which can readily be explained on well known principles.

The other supposed observational proof of Einstein's theory is equally lame. It is announced that it explains the motion of Mercury's perihelion, but any one familiar with the history of this subject knows that this has already been satisfactorily explained by the theory of gravitation. When Leverrier first discovered this residual motion he announced that the attraction of a planet inside Mercury's orbit would account for it. It is true that no such planet has been found, but the existence of a considerable mass of matter around the sun is clearly shown by the zodiacal light, and it has been conclusively proved (see POPULAR ASTRONOMY, Vol. 21, pp. 181-2) that the attraction exerted by this matter will explain not only the motion of Mer-

cury's perihelion, but that of Venus' node and Mars' perihelion as well.

The truth or falsity of Einstein's theory must of course be a matter of opinion merely until some really valid observational proof is forthcoming. Certain of the conclusions from it do not seem to accord with common sense, but the scientific mind will render no snap verdict.

Cincinnati Observatory, December 27, 1919.

REPORT OF THE AMERICAN METEOR SOCIETY FOR 1919

By CHARLES P. OLIVIER.

The report for 1918 appeared in POPULAR ASTRONOMY of January, 1920, and contained a brief statement of the progress of the reduction of all the observations sent in from 1914 to 1918 inclusive.

During the year 1919, due to causes not necessary to enumerate here, little attempt was made to have large numbers of observations made. However, work was done by 7 observers and 625 meteors were reported by them. The members contributing observations during 1919 were N. P. Ball, Sterling Bunch, R. M. Dole, John Koep, Walter Pattison, J. F. Peters, and C. P. Olivier. Mr. N. P. Ball of Colton, California, observed 354—the largest total reported during the year.

The most interesting single event reported was the appearance of a very brilliant meteor or meteorite on the afternoon of June 13. This appeared about 6 P. M., while the sun was high, and was observed from numerous places in eastern Virginia and Maryland. Inquiries were printed by the writer in several daily papers and many personal letters written. A large number of replies were received, but unfortunately, while they gave much very interesting information, not enough accurate descriptions of the actual path were given to make it possible to compute its orbit even approximately. It evidently moved from somewhere above the extreme southeastern part of Virginia toward Hagerstown, Maryland, over which place it was reported to have passed. It must have been an extremely brilliant object to have attracted such general attention during full daylight.

With the beginning of 1920, as the reduction of all the past observations is nearing completion, it is very important that the members should begin observing again with their former enthusiasm. This is the more desirable since the moon will be absent at the maxima of the most important showers in 1920, as the Perseids, Orionids and Geminids, and will only partly interfere with the Eta Aquarids. The Lyrids and Leonids will also be observed under very good conditions this year, though few meteors may be expected from either. It will be therefore seen that observations of the principal showers should be very successful, and the members are urged to make especial efforts to work on as many nights as possible during their activity.

A request has been made by Prof. W. H. Pickering that careful observations be made of very faint meteors which seem to have exceptionally high velocities. For them, if possible, the observer should fill every column of the record blank. He also asks that counts, similar to those made by him in Jamaica and described in POPULAR ASTRONOMY of 1917, p. 635-7, be made by other meteor observers.

In regard to our work it should be urged that, while there has been real progress toward the solution of some of the problems of meteoric astronomy from using the observations of the past few years, yet a beginning has scarcely been made as to others. Hence more members are urgently needed as we desire to seriously undertake their solution. The writer will be glad to hear at once from all members who were not able to work last year but feel that conditions will permit them to during this. Also from any other persons interested in meteoric astronomy who would care to have information about the work of the society with a view to joining. In conclusion it is hoped that the publication containing the results of the 22000 meteors observed from 1914 to 1918 inclusive will appear before this year is over.

Leander McCormick Observatory, University of Virginia. 1920, January 10.

THE USE OF SELENIUM CELLS IN ASTRONOMY.

By LEWIS J. BOSS.

Selenium is a non-metallic element, occupying the intermediate space between Sulphur and Tellurium. It was discovered in 1817 by Berzelius while he was experimenting with the Falun pyrites, with a view towards producing sulphuric acid from them. Selenium is obtained in three different forms, namely, amorphous, vitreous, and colloidal selenium. There is also another modification of selenium, known as metallic selenium. Of these we need only be concerned with the vitreous and metallic forms.

The metallic form of selenium is produced from the vitreous generally, and is the only modification of the element which is light sensitive. The vitreous selenium is gradually heated until the temperature approaches 100° C and then begins to pass rapidly into the metallic state, the temperature rising to 217° C.

This metallic selenium conducts electricity and exposure to light increases its conductivity. This effect is most pronounced when selenium is used which has been exposed for a considerable time to a temperature of 210° C, until it has attained a granular crystalline structure.

This final annealing is very essential to making the most sensitive and delicate cells. The selenium must be as pure as possible, as Marc has observed that impure selenium does not crystallize as well in a given time as does pure selenium. As a matter of interest it might be well to note here that in selenium crystals an X-ray analysis shows the selenium atoms to be placed at the corners of triangles in such a manner as to form hexagons. The distance betwen these atomic centers is 3.69×10^{-8} cm when measured perpendicular to a regular surface running parallel to the principal axis. These hexagonal plates are fitted one against the other lengthwise, so as to build up an acicular hexagonal crystal. The distance between these as shown by the X-ray spectrum seems to be 3.7×10^{-8} cm, or .037 millionths of a centimeter.

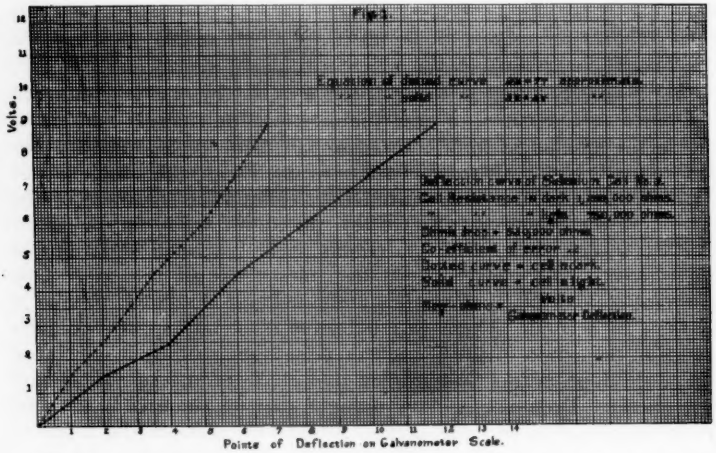
After this crystalline state has been attained by the selenium cell it becomes very sensitive to even the most minute changes and variations in the amount of light allowed to fall upon it. Grupenberg has produced cells which recorded changes of one-hundredth candle power at a distance of a mile. As Marc has calculated the thickness of the selenium layer which is affected by the light action to be about 1/1,500,000 inch thick, it can be readily seen that small variations in light intensity will greatly affect the conductivity of the cell. This change also takes place almost instantly, at least the lapse of time is less than .01 second. There does not seem to be any appreciable difference in the action of the cell whether the light striking it is colored or not, although no one has studied this phase of the subject to any great extent. Personally I have thought that on some cells at least, certain wave-lengths of light, notably λ 680-660 (between the B and C lines of the spectrum) affected them to a greater extent than did other portions of the spectrum. The conductivity of these cells was about 1000 times greater in strong light than in the dark.

The field of variable star observations seems to open up a vast field for the use of these cells in that they will detect the smallest changes in light variations where the eye could see no change whatever. Many stars, such as α Orionis whose period has never been determined, offer a field of great interest to observers who may elect to make use of these cells. By means of a suitable indicating device a continuous curve of light variations may be traced throughout the night.

These cells may be used in determining the relative amount of light given off by an eclipsed body and, if calibrated beforehand, could be made to read in direct light units. During lunar total eclipses they might be used to measure the amount of earth-light received by the moon.

Another use to which they might well be put is the comparison of magnitudes and brilliancy of stars. For instance let the cell be arranged to receive the light from star A (let us say); then after noting on the indicating device (galvanometer, etc.) the deflection produced by

the light of star A, swing the cell so that it receives the light from star B. If the deflection is the same, then star A and star B are of the same magnitude, but if the readings differ, then the proportion of difference in the readings is the proportion of difference in the magnitude. In this same way the cells might advantageously be used in recording brilliancy changes in Novae. Had such an apparatus been used on Nova Aquilæ last year I have no doubt but that some very interesting curves would have resulted.



The deflection curve of one of the cells in use here at the laboratory is shown in Fig. 1. This cell I hope to use this fall and winter in some if not all of the uses which I have outlined above and I look forward to having an extremely interesting set of curves.

The apparatus used in determining the accompanying deflection curve, was a very sensitive D'Arsonval Galvanometer, a volt-meter, constant voltage battery and an adjustable rheostat. The amount of light falling on the cell remained constant for the light curve.

In view of the great delicacy and sensitivity of these cells it is to be hoped that they will become the subject of more research in the future than they have in the past, and that they may aid in the advancement of man's most sublime science—Astronomy.

September 10, 1919.

ASTRONOMY IN THE HIGH SCHOOL.

By RUBY B. ALBERT.*

I have taken a place on this program very reluctantly, because I realize how little I can add to the information of men and women of your training, and that a person with such a limited experience as mine in the teaching of astronomy must open herself to criticism in attempting to tell others how it should be done. However, I have dared to hope that you believe it is more blessed to give than to receive and that by my presenting some of the problems of a teacher of high school astronomy and their solution, in so far as I have worked them out, you might be led to correct and supplement them.

One of the first difficulties one encounters is the great inequality in preparation of the students. I do not know of any high school that, so far, has made any subject prerequisite to the study of astronomy, and yet the principles of light, the laws of spectrum analysis and the fundamentals of spherical geometry are essentials. But to require physics and solid geometry before astronomy would cut down the available number to such an extent that most schools would not feel justified in making provisions for a class. Most instructors would rather teach these as part of the course than run the risk of barring from the class any one who is able to learn them—this because there is always a group who elect astronomy on account of its elements of romance and mystery. They have an idea that the course will be largely lecture work and consequently an easy one. The student who thus vaguely wishes to soar into the skies is apt to suffer a disappointment when he finds that astronomy does not consist in discussing the nebular hypothesis and in gazing through a telescope at the wonders there revealed. I take it that no science is well taught that does not give the student at least a certain minimum of facts, consisting of fundamental definitions and principles, of which he knows the meaning, and which he is able to use in the further acquisition of knowledge. Such a student as I have mentioned above is bound to get rather a hard jolt when he finds he must become familiar with a sphere in the class room before he can make much progress in studying the open sky. The celestial equator, the solstices and equinoxes, right ascension and declination, are in a way rather a disagreeable surprise to him. But most students, once they are safely past these, begin to awaken to the possibilities of the subject and to their own possibilities. Some to whom the word science has been a bug-a-boo

*Instructor in the North Side High School, Denver, Colorado. A paper read before the Science Section of the Colorado State Teachers Association, November 7, 1919.

through school, and who take astronomy because one year of science is required for graduation and astronomy appears to be the least scientific of the sciences, find a new world of interest open to them and a new power of their own to use.

The students of which I have been speaking however are not the great problem. To misuse an old adage, "ignorance is bliss," that is, the ignorance of the pupil is the bliss of the teacher. Our play habits as children persist in us now and while I am quite aware that pedagogy teaches that a child should be drawn out, an empty head has as much fascination as an empty pail in childhood and it is as much pleasure to fill it up as it was then to fill up the pail with sand from the sandpile.

The problem is with the student who comes to the class having had physics and most of the mathematics that the school has to offer. In addition to this he has gleaned from the popular scientific magazines almost as much about astronomy as other students will know at the end of the course. If it were possible I should like to have two classes for high school students in astronomy; one for those who read the Scientific American and Electrical Experimenter, and one for those who read the Photoplay Magazine.

The only solution of the difficulty I have arrived at as yet is that, after having ascentained that the lesson material assigned for the day has been prepared, the student is set to work on problems taken from books like Young's "General Astronomy," and Barlow and Bryan's "Elementary Mathematical Astronomy." Both of these books are rather formidable in appearance but have many interesting problems that are not too difficult for high school seniors. One of the nicest problems I know of and one that can be presented to the class in a clear cut way is given in Jacobi's Astronomy. It is a proof that Kepler's law of equal areas in equal times applies universally to all planetary motion and is a necessary consequence of Newton's law of gravitation. One can always find some pupil who will delight in studying this out and in presenting it to the class.

However, I must confess to having rather a single track mind. I like to teach a class that has at least the appearance that all the pupils are getting the same thing at the same time. While the present method of supervised study adapts itself better to the laboratory method than to the old lecture system, yet I still cannot help but feel that the inequality in preparation constitutes a real objection to astronomy as a high school subject.

Over against this objection there are to be placed numerous advantages to the pupil. Astronomy is the only science that takes our thoughts off this world. Its vast conceptions of time and space stretch the mind and give it a right perspective for other subjects. To give the student these conceptions, which seems to me to be one of the most important services of the subject, there is nothing that helps so much as ob-

servation. Now, the moment observation is spoken of the average person conjures up a vision of observatories and telescopes, and complicated star catalogues. Very few schools are the possessors of even a small telescope or a tripod to mount it on and with our students scattered over all parts of the city it is impractical and unnecessary to gather them together in the evening to work with an instrument that gives no valuable results. It would, however, be pleasant and profitable to take one or two trips to Denver University if one could find an evening with all conditions favorable.

What I mean by observation is a nightly look at the sky with a report the next day on what has been seen. Account should be taken of this in assignment of lessons. Of course there will be successions of cloudy evenings when other work may be given, but a large part of a student's outside preparation, when the conditions are favorable, should be this study of the sky. If astronomy is given in but one semester, the fall is preferable because the sky is then more apt to be clear and also twilight comes earlier. One cannot take too much of this observational work for granted. There should be definite evidence that observing is being done. Starting with Ursa Major and the Pole Star the catch figures can be picked out from a star chart and transferred to one page of a notebook. A list of questions can then be given that will lead the pupil to see the figure more quickly and will be a test of his work, e. g.: How many degrees from the Pole Star is the nearer pointer? Estimate the angle between two lines drawn from Mizar to the end of the handle and to Alcor respectively. Estimate the angle made by a line connecting the two stars at the top of the dipper bowl with horizontal line through either of them, noting the date and time and so on. Then the pupil may be required to make a drawing from the sky of the constellation as he sees it, putting in the horizon line and the zenith point and indicating the direction in which he was facing, the date and hour when the drawing was made. Questions may be given on the color of stars, though it takes some time to become expert in recognizing color. This work in becoming familiar with the constellations should be kept up during the entire course and later on, when the class can locate a star by its right ascension and declination, the constellation may be plotted on co-ordinate paper from a star catalogue rather than from the star charts. After this work is started questions begin to come in till sometimes it takes half the period to answer them. Some pupil in much excitement will announce that he has discovered a comet which turns out to be the great nebula in Orion. Though he may be incorrect in what he assumes this heavenly body to be, its discovery may prove quite as valuable to him as the discovery of a real comet. The planets, especially Jupiter and Saturn, play havoc with a beginner's constellation study and some publication like the little Monthly Evening Sky Map helps in keeping tract of the wanderers. While telescopes for observational

work may be ignored at first, later a suggestion to the class that they use an ordinary opera glass or field glass on the Pleiades and other star clusters has its own reward.

It is extremely interesting to watch the changes that take place in the attitude of the class in the course of a semester. The first week one has to ignore facetious remarks about "star-gazing", "moonlight nights", and so on, for it does not take a class long to become serious, sometimes too much so. Thinking of time in aeons of years and distance in light years soon has a sobering effect on the most lightminded pupil.

And here may be the justification of astronomy as a high school subject. The humorist Irving Cobb, in describing his ascent of some mountain in the Rockies, comments on the strange fact that a man will spend half a day in toiling up a mountain side and when he has reached the top, where the fruit of his labors is all spread out before him for his leisurely contemplation, he gives it but a few superficial glances at the most and hurries down. Cobb's explanation is that man's ego is uncomfortable on a mountain top. The vastness of nature makes him feel ill at ease. He feels dwarfed and insignificant. This may in a measure be the explanation of why astronomy is not more popular in the high school. The average youth is willing to take a superficial glance at the beauty of the stars but when it comes to contemplating vast distances, enormous masses and the stupendous forces that hold the universe in a nice balance, he feels his ego dwarfed into insignificance and I have suspected that the modern youth is just bright enough to sense this and keep a discreet distance from the subject.

There are always a few brave souls however who wish to study astronomy, just as there are always a few people to whom the glory of a mountain top is worth the climb to attain it. If the greater part of the population of our Colorado cities could be induced to climb a mountain, even once a year, could you imagine the effect it would have on the health and spirits of the people? And—since I seem to be following this figure of speech—if the greater part of the high school pupils of our country could be induced to take astronomy I venture to say the results would be evidenced in more reverence, more humility, and more orderly living. It might even be a cure for Bolshevism.

Just how they can be induced to take astronomy however is a question. Two years ago the mathematics teachers of the North Denver High School, feeling that many students were not electing mathematics who would really need it in their work later on in college, prepared a poster giving the lines of work in which it is desirable. This was placed in the main corridor and seemed to answer its purpose. Last year, the teachers of Latin acting on a similar impulse, prepared an elaborate exhibit, consisting of some thirty posters, setting forth the

advantages of a knowledge of Latin. Classes from the eight grades of several grade schools were brought to see it before making out their course of study. An inquiry was made of the present beginning classes as to how they had been impressed. Fifteen out of 104 beginners attributed their taking Latin to seeing this exhibit. This may be a little high owing to the power of suggestion.

To some it may seem rather an unusual procedure and beneath the dignity of subjects like Latin, Mathematics and Astronomy, this advertising one's subject as one would advertise wares for sale. But to me it appears to be one method of solving the problem of vocational guidance, provided all of the subjects given in high school could be presented in the same way to students making out their courses of study. At present, the pleasant click of the cunning little machines in the typewriting room has a magical drawing power. They are all the advertising that department needs, but ten or twenty years from now these pupils who are now in high school are going to say "Why didn't I know about these other courses?" But as a race we are fast losing the missionary spirit. The laissez-faire doctrine has crept into modern education disguised under the name of the elective system, so I fear astronomy will not come into its own until the pendulum swings back the other way and educators begin to realize that the average child needs more direction in choosing his course of study than he is now getting.

A NEW THEORY OF THE DELUGE.
(Correlating Science with Genesis.)

By H. P. LEE.

There are scattered through space vast clouds of matter called nebulæ. These are found with almost every conceivable degree of temperature, luminosity, size and density (or, rather, tenuity). Ages ago, the solar system plunged into one of these nebulæ. It was of such vast extent as to require at least 2000 years to pass through. Its temperature was little, if any, above that of space. Its tenuity was such as to permit the passage of the visiting orbs with practically no friction. Yet it was dense enough to absorb sufficient warmth from the sun to keep the temperature of the earth approximately the same everywhere and at all times during the year.

The results of this event would naturally be as follows:

(1). There was no rain during this period because rain is caused by a sudden chilling of the atmosphere, whereas such changes were now impossible. This phenomenon is thus recorded in the Book of Genesis: "The Lord God had not caused it to rain upon the Earth,..

....but there went up a mist from the earth, and watered the whole face of the ground" (Genesis 2:5, 6). Here is doubtless the most primitive fact handed down by human tradition. How else can we account for it? Of course we must assume the mist to have been a very heavy one,—perhaps even an "Oregon mist," or drizzle, because we read of rivers of great length, whatever their size.

(2). The second effect of equalizing and stabilizing the earth's temperature was the melting of the polar ice-caps and the development of tropical life in the polar regions. In no other way can this mysterious phenomenon be so well explained.

(3). The third effect was the accumulation of the oceans in the sky, due to the fact that evaporation was constant and normal while precipitation was slight,—far less than enough to balance the evaporation.

(4). The fourth effect was that the sun became obscured, hence the distinction between night and day was decidedly less marked than at present, even during our cloudiest weather.

(5). There was no summer and winter because the nebula stabilized the temperature throughout the year. Besides, the difference between summer and winter, as well as that between the poles and the tropics is caused by the varying angles with which the sun's rays strike the earth, whereas now these rays were interfered with both by the nebula and by the dense clouds that held the oceans suspended in the skies.

(6). There would be no distinction between seedtime and harvest, because the farmer could sow at any time of the year and reap as soon as the crop matured.

(7). In this twilight world, devoid of extreme changes from light to darkness and from heat to cold, and at a temperature most favorable to the perfection of animal life, man developed more slowly and decayed more slowly than under the present conditions. Thus we read in the fifth chapter of Genesis that Seth was 105 years old before he begat his first-born, Methuselah was 187 years old, and the youngest age at which any of them became a father was 65 years. This precocity seems to have been exhausting because the two men who begat sons at that tender age were the shortest-lived of the ante-diluvians, while the two longest-lived men were those who were most mature at the birth of their eldest son.

In due time the Solar System emerged from the nebula, which had acted as a hothouse, into the cold outdoors of space. What must have been the result?

(1). The chilling of the atmosphere suddenly condensed the ocean of clouds in the sky and for forty days and forty nights there was the most terrific downpour of rain. Moreover, the small oceans were over-

flowed, for "the fountains of the great deep were broken up", "and the waters prevailed and were increased gently upon the earth" (Genesis 7:11-20). Naturally the population, then as now, tended to settle near the ocean, diminished as it was after over 2000 years of evaporation compensated only by the drizzle before described. The downpour overflowed these oceans to such an extent as to cover "all the high hills that were under the whole heaven", that is, all the elevations in the part of the earth then inhabited. The universality of this destruction is attested by the fact that practically every race has a tradition of a deluge.

(2). In Siberia and other polar regions, the deluge came as snow and hail. Hence the mammoths of Siberia were engulfed in cliffs of ice where their remains can be seen to this day.

(3). And now, behold, for the first time, a rainbow, the pledge that never again shall the earth be subjected to a deluge. Previously the thick masses of clouds had hidden the sun uninterruptedly. But while there is so little moisture in the sky as to permit the sun to be seen, and the rainbow to be reflected there is no danger of another deluge. "I do set my bow in the cloud, and it shall be for a token of a covenant between me and the earth. And it shall come to pass when I bring a cloud over the earth, that the bow shall be seen in the cloud; And I will remember my covenant, which is between me and you and every living creature of all flesh; and the waters shall no more become a flood to destroy all flesh" (Genesis 9:13-15).

(4). The sun being now directly visible, there was a far more noticeable distinction between day and night.

(5). Summer and winter now became seasons as at present.

(6). It was now necessary to plant in the springtime and harvest accordingly. In other words, there was a definite time for seeding and a definite time for harvest.

The foregoing three facts are thus expressed in Genesis: "While the earth remaineth, seedtime and harvest, and cold and heat, and summer and winter, and day and night shall not cease" (Genesis 8:22). This implies a primitive tradition that there was a time when there was no definite time for planting and reaping, no changes from hot to cold in the atmosphere, no summer and no winter, and no such sharp distinction between night and day as at present.

There seems also to have been connected with the ante-diluvian climate a special curse to the ground, probably from the presence of vegetation induced by the special conditions already described. "Cursed is the ground for thy sake....Thorns also and thistles shall it bring forth to thee....In the sweat of thy face shall thou eat bread" (Genesis 3:17-19). But in chapter 4:29, we read that Lamech prophesied of Noah, "This same shall comfort us concerning our work and toil of our hands, because of the ground which the Lord hath cursed". Hence we may conclude that the "Sweat of the face" was caused by the exces-

sive labor of combatting these thorns and thistles. But the sunlight must have killed these noxious weeds because we read in chapter 8, verse 21, as follows: "And the Lord said in His heart, 'I will not again curse the ground any more for man's sake'."

(7). Immediately after the flood we find a shortening of human life. Noah lived to be 950 years of age, Shem, 600 years, Arphaxad, 438, Salah, 433, Eber, 464, Peleg, 239, Reu, 237, Serug, 230, Nahor, 148, (begetting his firstborn at the age of but 29, the youngest age up to that time), Terah, 205, (begetting his son at the age of 70, the oldest for many generations), Abraham, 175, Isaac, 180, Jacob, 147, Joseph, 110, Moses, 120. Evidently then, the ante-diluvian conditions were markedly different from the post-diluvian conditions, and they were as markedly more favorable to longevity. And, incidentally, there seems to be a casual relation between late marriages and longevity.

If we assume that the nebula was traveling in the same direction as the Solar System, we need not assume as large dimensions for it, in order to account for the length of time required for us to pass through it.

Many times has Science thrown helpful light upon the meaning of the Bible narrative. The foregoing is an attempt to repay the debt by showing that the Bible may sometimes become an aid to Science. Does it not suggest the ultimate harmony of Science and Theology?

Box No. 230, Portland, Oregon.

ASTRONOMY IN DAILY LIFE.

By GILBERT P. CHASE.
Commander, U. S. Navy.

Trace back the records of mankind to the beginning; we find the study of the heavens in the minds of primitive men as one civilization after another looms up out of mists of antiquity.

In the beginning God created the heavens and the earth. Light was the work of the Creator on the first day. Then was made the firmament, which was called Heaven; and the evening and the morning were the second day. How many seconds there were in those days of creation has not yet been determined either by Religion or Science. No doubt they were longer than what we now call days, altho to God they may have seemed very short, because he was evidently interested in the work. To geologists a "day" in the creation of the world is infinitely longer than the ordinary day—almost as long as the day of the soldier in France waiting for the transport to sail for home. However

that may be, we find, as we would expect to find after reading the first few verses in the Bible that light and the firmament first engaged the mind of primitive man in that study which afterwards developed into the science of Astronomy. I have begun this way to persuade my benevolent readers that, although I am a seaman, I am not to be classed among the ungodly.

One may develop a fondness for architecture, chemistry, law, medicine, or shipbuilding; but unless one of these subjects be selected for a profession in life, one will become aware of the limitation in continuing the study for the sake of personal interest. Of all the sciences or subjects taught in the colleges, there is none that offers in so prominent degree the inducements of both vocation and avocation, and no learned profession that can look back upon a longer line of succession of its exponents than Astronomy. Every century of recorded history has added something to the fund of accumulated knowledge. Those who now choose this field of research will not find the soil exhausted and unproductive. Unknown elements in the universal make-up, laws operating beyond the bounds of human knowledge, and the mechanical means of research, are lying in wait for the searching mind of today as they were for the mind of Hipparchus, Copernicus, Kepler, Newton, and Galileo. This most ancient, this most uncommercial, this most unselfish of all the sciences, still allures the consecrated searcher for truth with those same attractive problems, the solution of which has absorbed the most prodigious labors of the mind of man and crowned the highest achievements of the human intellect. For those of every profession, occupation, and station in life, Astronomy offers an unbounded field for harvesting and gleaning that kind of knowledge which brings benefit, pleasure, and satisfaction; leading from the familiar sunshine and moonbeam to the association and companionship with those distant worlds, those celestial movements that broaden the mind and draw the human soul more and more into the Universal Harmony.

Next to the professional astronomers, there are perhaps no people whose daily life brings them more into the knowledge of the heavenly bodies than seamen and navigators. Water covers nearly three-fourths of the surface of the globe. Europe, large enough to make a battlefield for all the armies of the world with room to spare, covers only 1.9 percent of the surface of the earth, while the Pacific Ocean covers 35.5 percent. It is that part of Practical Astronomy known as Nautical Astronomy that enables the mariner to find his way over the unmarked paths of the ocean deeps, and to head with confidence for the object of his voyage in spite of the varying currents and the winds and waves of stormy weather that toss him about and render his course and speed uncertain. Without a mark on land to guide, without a sounding in the practically fathomless waters, after days of storm and wind and rain and clouded sky, the watchful seaman snatches the cotton ball of

the sun, the moon, a planet, or a star from under a cloud, brings it down in his sextant to a clearing on the horizon, finding the position of his ship, from which he shapes his course clear of all dangers, to the landfall he would make. The mariner who has so many times called upon these celestial companions on the watery desert to aid him on his way, will forever after regard them as his friends, and be thankful to them for their kindly light which leads so many of his kind amidst the encircling gloom.

The farmer, the hunter, the builder, the traveler, and all those who follow the fundamental occupations which supply the human race with the means of living, regulate their daily life by the rising and setting of the sun, the phases of the moon, and the seasons; that is to say, they are governed by Astronomy in its simple and elementary form. The animal herds and flocks, prompted by instinct, move and live in conformity with the seasonal changes, produced by the operation of those universal laws formulated in the earlier days of the development of the science of Astronomy, and handed down to us by successive generations from an age so remote as now to be almost unconscious knowledge. All nature, in fact, exists in the light and heat of the sun, knowledge of which is given to us by the science of Astronomy.

The habit of daily observing the heavens, and of reading whatever comes to hand in form suited to individual needs about Astronomy and the heavens, will be found useful in all our observation and reading. In the fancy of the poet, an angel contemplating our earthly abode says:

"And swift and swift beyond conceiving,
The splendor of the world goes round,
Day's Eden brightness still relieving
The awful night's intense profound.
The ocean tides in foam are breaking,
Against the rocks' deep bases hurled,
And both the spheric race partaking,
Eternal, swift, are onward whirled."

A familiarity with the axial and orbital motion of the earth will add to the appreciation of these lines. Hear this also:

"We buried him darkly at dead of night,
The sods with our bayonets turning,
By the struggling moonbeams' misty light,
And the lantern dimly burning."

The struggling moonbeams' misty light. How real, how natural, how actual that sounds! Take away the moonbeams, and we feel that there could be no funeral. Scientists, we hope, are generous in their interpretation of the poetic license. Let the poet who looks at the almanac for the year and day of the Battle of Corunna be generous too: if he should find there was no moon on that night, it would be unkind of him to say that the scientists erred in compiling the almanac.

The great Lincoln, while practicing law, asked a witness how he could see a thing at night that he had just testified about. The witness said:

"By the moonlight".

Lincoln produced an almanac showing there was no moon that night. He won the case.

The Admiral of the *Ocean Sea*, shipwrecked on the island of Jamaica on his last voyage to the New World, saved himself and his surviving shipmates by making use of a known eclipse of the moon. The terrified Indians deemed it unwise to incur the displeasure of a human being who could put out the moon at will, and continued to bring the food that sustained the unfortunate mariners. A similar incident is related in the life of Captain John Smith. These are instances of a knowledge of Astronomy saving a man's daily life.

About a month ago I was looking for a name beginning with "R" in the Encyclopedia Britannica, Volume 23, Edition 11, in the New Orleans Public Library. What I wanted was not to be found, but I felt well repaid for my time and labor when I ran across this:

> "RIGHT ASCENSION, in Astronomy, that co-ordinate of a heavenly body defined by the angle which the meridian passing through it makes with the prime meridian through the vertical equinox."

Vertical Equinox! That might be all right for *Life* or *Judge*, but for the Encyclopedia Britannica! Truly there is always something more to learn. It was my desire to know more about Astronomy that lead me to pick up this rare bit.

Artists who paint the new moon over the landscape should have a care about which way the "horns" of the crescent point. If they would paint the sunset, they will do well to have at hand a sunset table for the time and place. If they would sit by the seashore and portray the orb of day emerging from the ocean deep, they will do well to know beforehand at what minute the crown of that subdued but not extinguished ball of fire will rupture the unbroken line of the sea horizon.

New Orleans, 15 December 1919.

TOTAL ECLIPSE OF THE MOON, 1920 MAY 2.

By WILLIAM F. RIGGE.

A total eclipse of the Moon with the magnitude 1.22 will be visible on May 2, to some extent at least, all over the United States. The annexed figure will give the particulars.

The largest circle with the cardinal points N S E W represents a section of the penumbra, and the next in size the umbra, where the

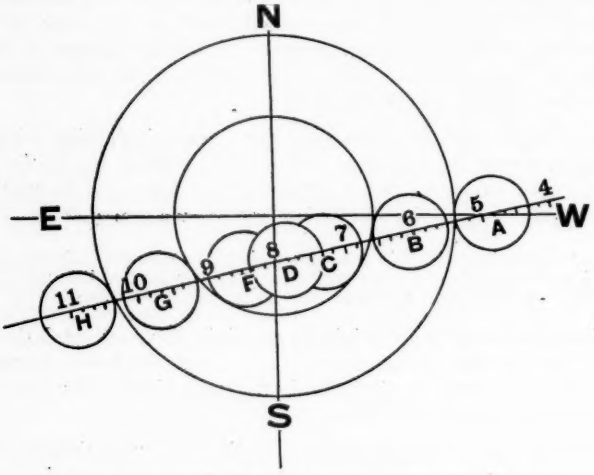


DIAGRAM OF TOTAL ECLIPSE OF THE MOON, 1920 MAY 2.

Moon will cross them. The seven small circles show the Moon at important moments. When it is at A at 4:49 P. M. Central Time the Moon enters Penumbra. At B at 6:01 the Moon enters Shadow. At C at 7:15 the Total Eclipse begins. At D at 7:51 we have the Middle of the Eclipse. At F at 8:27 the Total Eclipse ends, after having lasted one hour 12 minutes. At G at 9:41 the Moon leaves Shadow, and at H at 10:53 the Moon leaves Penumbra.

The eclipse will take place mostly during the evening twilight, so that it will be deprived of much of its impressiveness. Its visibility in the various states may be gauged somewhat by the fact that at Omaha the Moon will rise at 7:18, three minutes after having become totally eclipsed, and the Sun sets at the same time.

PLANET NOTES FOR APRIL 1920.

The *sun* will continue a northeasterly course during this month. At the end of the month its position will be nearly 15 degrees north of the equator. It will move from the constellation Pisces into the constellation Aries. It will not be near any conspicuous stars, although at the end of the month it will be approaching the position of the Pleiades.

The phases of the *moon* for the month are as follows:

Full Moon	April	3	at 5:00	A.M.	C.S.T.
Last Quarter		11	at 7:00	A.M.	"
New Moon		18	at 4:00	P.M.	"
First Quarter		25	at 7:00	A.M.	"

The moon will be nearest the earth on April 20 and will be at its farthest point on April 8.

Mercury will reach a position of greatest elongation west on April 16. It will, however, be several degrees south of the sun at this time and will, therefore, not rise long enough before the sun to make it easily visible to northern observers. It may, however, be seen near this date if one knows exactly where to look for it and with the aid of a pair of field glasses.

Venus will continue its motion eastward during this month at almost an equal pace with the sun, remaining, on an average, about an hour and a quarter west of the sun. It will cross the equator from south to north on April 15. Because of its nearness to the sun it will not attract any attention during this month.

Mars will continue to be favorably situated for observation during this month. In fact, it will be in its best position for the year as it reaches opposition on April 20. It however, will be nearest the earth on April 27. At this time it will be about 55,000,000 miles from the earth. This opposition, therefore, is not one of nearest approach to the earth, as it sometimes comes to within 35,000,000 miles of the earth.

Jupiter will be in quadrature with the sun, 90 degrees east, on April 29, and will, therefore, be on the meridian at sunset near this date. Jupiter will therefore be a brilliant object in the western sky in the evening during the month of April.

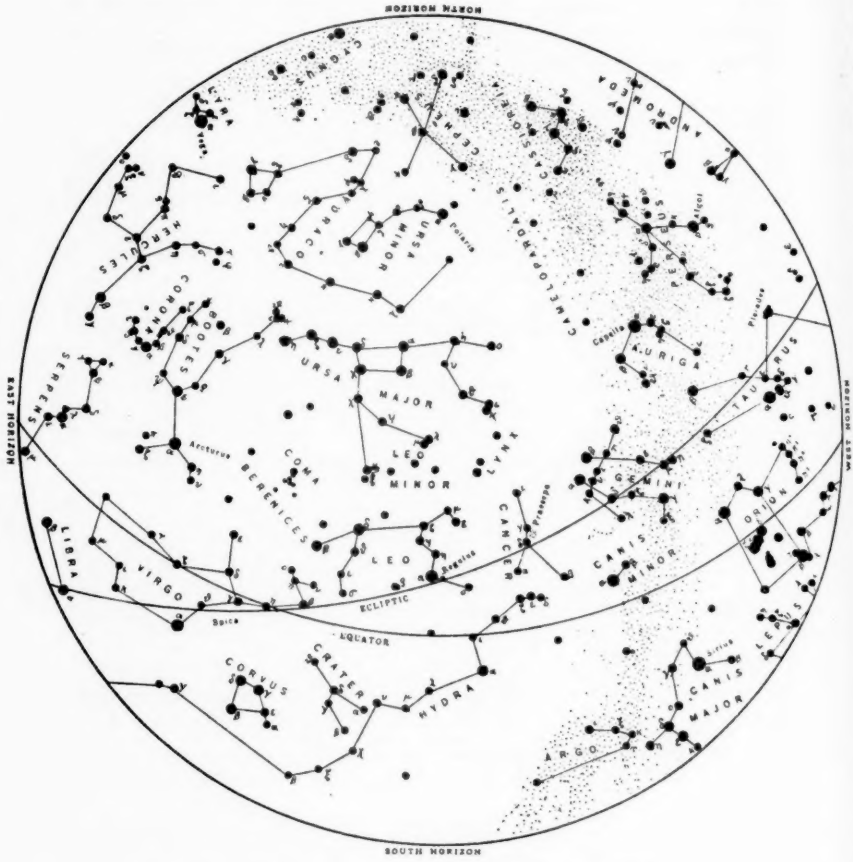
Saturn will be a few hours east of Jupiter and a few degrees south. It will be moving slowly westward in the constellation Leo, a short distance east of Regulus.

Uranus will rise a little while before the sun and may be seen by northern observers with the aid of a telescope on the southeastern horizon just before sunrise.

Neptune will reach quadrature, 90 degrees east of the sun, on April 29, just eight hours before Jupiter. Neptune will then be about two degrees south of Jupiter. This planet, therefore, may be well observed throughout the month.

The Constellations on April 1 at 9:00 P. M.

Many persons, who have never given any particular thought to the matter, regard the appearance of the sky to be the same from night to night. This view, however, is entirely erroneous. Any one who will take the necessary time to familiarize himself with the configurations of the stars at a given hour on a certain night, and will then observe the sky after the lapse of one month at the



The Constellations at 9:00 p. m., April 1, 1920.

same hour of the night, will notice a general drift of the stars towards the west. In attempting to do this, at first one feels at a loss for a means of identifying the stars and thereby fixing definite points of reference. This feeling will somewhat be removed if one knows the names of a few of the stars he is looking at. It

will, therefore, be of interest to know what constellations and bright stars are visible at a given time. From the accompanying chart it will be seen that on April 1 at 9:00 P. M. the "Pointers," the two stars in the bowl of the "Great Dipper" which are in line with the North Pole Star, will be very nearly in the meridian, about two-thirds of the distance from Polaris to the zenith, for an observer at about 45 degrees north. The rest of the "Great Dipper" lies to the east of the meridian. About the same distance south of the zenith as the "Pointers" are to the north and a trifle west of the meridian, will be found the bright star Regulus in the constellation Leo. West of Regulus, a little more than half the distance to the horizon, will be seen the bright star Procyon in the constellation Canis Minor. Starting from Procyon and going towards Polaris about one-fourth of the way, one will find the "Twins", Castor and Pollux. Toward the western horizon from Procyon will be found Sirius in the constellation Canis Major and Betelgeuse in the constellation Orion, making an equilateral triangle with Procyon. Still nearer the horizon may be seen the "Belt" of Orion, a short distance south of the west point. About the same distance from the horizon as the "Belt" of Orion, and the same distance north of west as the "Belt" is south of west will be found the bright star Aldebaran in the constellation Taurus. A little above the line joining Aldebaran to Polaris, and not quite half the distance, will be found the star Capella in the constellation Auriga.

In the eastern sky one's attention will be attracted by Spica in the constellation Virgo in the southeast, and by the brilliant, yellowish star Arcturus in the constellation Bootes, about half way between the east point and the zenith. In the northeast near the horizon, Lyra with the bright star Vega will be rising.

This description of the sky will be approximately correct for 10:00 o'clock on April 1 and for 8:00 o'clock on April 30.

Occultations Visible in the United States, April, 1920.

[NOTE:—Geographical positions are indicated by giving for each point, first the latitude, then the longitude, the two being separated by a hyphen. A line drawn on a map through the two or three points thus indicated will mark approximately the region of visibility for the U. S.

The time given is the approximate Greenwich time of the middle of the occultation, as visible in the U. S.]

Apr. 1, 11^h. 431 B. Leonis, Mag. 6.2. East of long. 76°. (Farther west, occurs before sunset.)

Apr. 2, 18^h. χ Virginis, Mag. 4.8. Throughout the U. S. except northeast of 50°-94°, 45°-85°, 39°-74°.

Apr. 6, 15^h. 47 Libræ, Mag. 5.8. East of 28°-92°, 35°-88°, 42°-81°, and south of 42°-81°, 39°-73°.

Apr. 6, 21^h. β Scorpii, Mag. 2.9. South of 43°-125°, 34°-106°, 30°-90°, 32°-77°.

Apr. 6, 21^h. 56 B. Scorpii, Mag. 5.0. South of 42°-125°, 33°-105°, 30°-90°, 31°-80°.

Apr. 10, 18^h. ρ Sagittarii, Mag. 4.0 East of 25°-86°, 32°-83°, 36°-79°, and south of 36°-79°, 35°-75°.

Apr. 10, 18^h. 45 Sagittarii, Mag. 6.0. East of 48°-82°, 40°-82°, 33°-79°.

Apr. 11, 23^h. 16 B. Capric., Mag. 6.2. South of 36°-124°, 36°-106°, 40°-92°. (East of long. 92°, occurs after sunrise.)

Apr. 11, 23h. β Capricorni, Mag. 3.2 South of 38°-125°, 38°-106°, 41°-94°, (East of long. 93°, occurs after sunrise.)

Apr. 12, 23h. ν Aquarii, Mag. 4.5. South of 32°-120°, 32°-102°, 35°-90°. (East of long. 90°, occurs after sunrise.)

Apr. 16, 1h. λ Piscium, Mag. 4.6. South of 47°-125°, 49°-118°, and west of 49°-118°, 26°-98°. (Farther east, occurs after sunrise.)

Apr. 21, 12h. 312 B. Tauri, Mag. 6.2. Northeast of 33°-92°, 30°-81°, and east of long. 92°. (Farther west, occurs before sunset.)

Apr. 21, 17h 333 B. Tauri, Mag. 6.3. South of 46°-124°, 42°-112°, 37°-100°, and west of 37°-100°, 28°-101°.

Apr. 22, 19h. 19 B. Gemin., Mag. 6.2. West of 33°-121, 42°-110°, 50°-99°.

Apr. 23, 14h. 110 B. Gemin., Mag. 6.2. Throughout the U. S. except northeast of 45°-74°, 43°-70°. (West of 32°-118°, 50°-106°, occurs before sunset.)

Apr. 23, 20h. λ Gemin., Mag. 3.6. Northwest of 42°-125°, 50°-116°.

Apr. 25, 13h. 60 Cancri, Mag. 5.7. East of 30°-111°, 42°-99°, and southwest of 42°-99°, 38°-90°, 32°-78°. (Farther west occurs before sunset.)

Apr. 27, 21h. 237 B. Leonis, Mag. 6.3. North of 33°-120°, 32°-106°, and west of 32°-106, 40°-100°, 50°-93°.

Apr. 27, 21h. 55 Leonis, Mag. 6.1. West of 38°-124°, 45°-121°, 50°-118°.

Apr. 28, 13h. 388 B. Leonis, Mag. 6.3. East of long. 95°. (Farther west, occurs before sunset.)

Apr. 29, 11h. 78 B. Virg., Mag. 6.5. East of 40°-74°, 48°-68°. (Farther west, occurs before sunset.)

Apr. 30, 15h. 49 Virginis, Mag. 5.2. Northeast of 50°-106, 42°-87°, 35°-75°.

Apr. 30, 15h. 50 Virginis, Mag. 6.2. Southwest of 50°-118°, 40°-94°, 30°-78°.

ARTHUR SNOW,
Ass't, Nautical Almanac, U. S. Naval Observatory.

Saturn's Satellites.

[From the *American Ephemeris.*]

CENTRAL STANDARD TIME.

I. Mimas. Period 0d 22h.6.

1920	d	h		d	h		d	h		d	h
Apr.	1	16.1 W	Apr.	8	06.5 W	Apr.	15	08.1 E	Apr.	22	09.7 W
	2	14.8 W		9	16.4 E		16	06.7 E		23	08.4 W
	3	13.4 W		10	15.0 E		17	16.6 W		24	07.0 W
	4	12.0 W		11	13.6 E		18	15.3 W		26	15.5 E
	5	10.6 W		12	12.2 E		19	13.9 W		27	14.1 E
	6	09.2 W		13	10.8 E		20	12.5 W		28	12.8 E
	7	07.8 W		14	09.5 E		21	11.1 W		29	11.4 E
										30	10.0 E

II. Enceladus. Period 1d 8h.9.

Apr.	1	11.1 E	Apr.	9	16.4 E	Apr.	16	12.8 E	Apr.	23	09.3 E
	2	20.0 E		11	01.3 E		17	21.7 E		24	18.2 E
	4	04.9 E		12	10.2 E		19	06.6 E		26	03.0 E
	5	13.8 E		13	19.1 E		20	15.5 E		27	11.9 E
	6	22.7 E		15	04.0 E		22	00.4 E		28	20.8 E
	8	07.6 E								30	05.7 E

III. Tethys. Period 1d 21h.3.

Apr.	2	13.0 E	Apr.	10	02.2.E	Apr.	17	15.4 E	Apr.	25	04.7 E
	4	10.4 E		11	23.5 E		19	12.8 E		27	02.0 E
	6	07.6 E		13	20.8 E		21	10.1 E		28	23.3 E
	8	04.9 E		15	18.1 E		23	07.4 E			

IV. Dione. Period $2^d\ 17^h.7$.

	d	h		d	h		d	h		d	h	
Apr.	3	02.6	E	Apr. 11	07.6	E	Apr. 19	12.7	E	Apr. 27	17.7	E
	5	20.3	E	14	01.3	E	22	06.3	E	30	11.4	E
	8	14.0	E	16	19.0	E	25	00.0	E			

V. Rhea. Period $4^d\ 12^h.5$.

Apr.	1	18.9	E	Apr. 10	19.7	E	Apr. 19	20.4	E	Apr. 28	21.2	E
	6	07.3	E	15	08.1	E	24	08.8	E			

VI. Titan. Period $15^d\ 23^h.3$.

Apr.	2	12.8	E	Apr. 10	06.9	W	Apr. 18	10.8	E	Apr. 26	05.1	W

VII. Hyperion. Period $21^d\ 7^h.6$.

Apr.	2	21.2	W	Apr. 14	02.4	E	Apr. 24	01.5	W			

VIII. Iapetus. Period $79^d\ 22^h.1$.

Apr.	1	16.6	S							Apr. 22	07.4	E

IX. Phoebe. Period $523^d\ 15^h.6$.

		α Ph.—α Sat.		δ Ph.—δ Sat.			α Ph.—α Sat.		δ Ph.—δ Sat.	
		m	s	′	″		m	s	′	″
Apr.	2	+0	29.8	−0	52	Apr. 18	+0	09.9	+1	18
	4	0	27.4	0	36	20	0	07.3	1	34
	6	0	24.9	0	20	22	0	04.8	1	50
	8	0	22.9	−0	03	24	+0	02.2	2	06
	10	0	19.9	+0	13	26	−0	00.3	2	21
	12	0	17.4	0	29	28	0	02.8	2	37
	14	0	14.9	0	45	30	−0	05.4	+2	52
	16	+0	12.4	+1	02					

Phenomena of Jupiter's Satellites.

VISIBLE AT WASHINGTON.

[From the *American Ephemeris.*]

CENTRAL STANDARD TIME.

1920	d	h	m			April	d	h	m		
April	1	7	30	IV	Tr. I.		14	12	50	II	Tr. I.
		10	06	I	Oc. D.		16	7	42	II	Oc. D.
		12	12	IV	Tr. E.			9	16	III	Ec. R.
		13	34	I	Ec. R.			11	09	I	Tr. I.
	2	7	26	I	Tr. I.			12	23	I	Sh. I.
		7	52	II	Ec. R.		17	8	19	I	Oc. D.
		8	33	I	Sh. I.			11	53	I	Ec. R.
		9	42	I	Tr. E.		18	6	52	I	Sh. I.
		10	50	I	Sh. E.			7	33	II	Sh. E.
	3	8	02	I	Ec. R.			7	54	I	Tr. E.
	5	7	03	III	Tr. I.			9	08	I	Sh. E.
		10	40	III	Tr. E.			12	07	IV	Sh. I.
		11	48	III	Sh. I.		19	6	22	I	Ec. R.
	7	10	18	II	Tr. I.		23	8	06	III	Oc. R.
		12	43	II	Sh. I.			9	37	III	Ec. D.
		13	10	II	Tr. E.			10	14	II	Oc. D.
	8	11	58	I	Oc. D.		24	10	13	I	Oc. D.
	9	9	17	I	Tr. I.		25	7	17	II	Sh. I.
		10	27	II	Ec. R.			7	31	I	Tr. I.
		10	28	I	Sh. I.			7	35	II	Tr. E.
		11	33	I	Tr. E.			8	46	I	Sh. I.
		12	44	I	Sh. E.			9	48	I	Tr. E.
	10	6	26	I	Oc. D.			10	11	II	Sh. E.
		8	42	IV	Ec. R.			11	02	I	Sh. E.
		9	58	I	Ec. R.		26	8	18	I	Ec. R.
	11	7	13	I	Sh. E.			9	36	IV	Oc. D.
	12	10	51	III	Tr. I.		30	8	25	III	Oc. D.

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by members of the Class in General Astronomy in Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1920 April							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8								
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	7 21;	15 14;	23					
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	6 3;	13 13;	21	0;	28	11		
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	3 20;	11 7;	18	19;	26	2		
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	1 1;	7 4;	19	9;	25	16		
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	3 20;	10 23;	18	3;	25	7		
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	2 6;	9 3;	22	20;	29	10		
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	5 22;	13 2;	20	6;	27			
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	8 23;	17 18;	26	13				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	5 11;	13 9;	21	8;	29	7		
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	8 2							
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	4 4;	9 21;	21	9;	27	3		
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	7 6;	14 1;	20	20;	27	15		
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	8 22;	16 19;	24	17				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	2 19;	11 3;	19	10;	27	17		
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	3 16;	11 14;	19	11;	27	8		
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	5 7		18	12				
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	5 8;	14 18;	24	6				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	3 23;	16 10;	28	20				
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	2 17;	9 9;	22	17;	29	9		
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	3 11;	11 15;	19	20;	28	0		
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	2 20;	8 20;	20	21;	26	22		
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	4 2;	12 17;	21	10;	30	2		
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	2 11;	12 21;	23	7				
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	6 0;	14 1;	22	1;	30	1		
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	5 9;	11 3;	22	14;	28	7		
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	6 10;	12 0;	23	5;	28	20		
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	8 23;	17 4;	25	9				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	7 23;	15 14;	23	5;	30	20		
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0		11 1;	23	6				
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	3 19;	10 0;	18	4;	25	8		
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	1 21;	8 8;	22	9;	29	3		
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	8 18;	18 2;	27	9				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	6 15;	13 6;	19	20;	26	11		
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	3 20;	12 5;	20	15;	29	1		
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	1 12;	7 23;	20	19;	27	6		
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	2 5;	9 12;	16	18;	24	1		
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	3 5;	11 8;	19	11;	27	14		
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	1 20;	11 7;	20	19;	30	6		
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	5 15;	12 11;	19	8;	26	4		
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	5 8;	11 6;	17	5;	29	1		
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	3 1;	9 19;	23	7;	30	0		
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	5 7;	12 17;	20	3;	27	13		
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	4 0;	10 14;	23	19;	30	10		
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	2 19;	11 14;	20	10;	29	5		
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	2 0;	9 8;	16	16;	23	23		
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	5 4;	11 23;	17	18;	25	12		
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	7 12;	15 0;	22	12;	30	0		
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	2 20;	12 10;	22	1				
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	1 5;	8 16;	23	12;	30	23		
133926 Hydrae	13 39.0	−26 23	8.6—12.7	2 21.5	3 0;	8 19;	20	9;	26	4		
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	4 11;	11 10;	18	10;	25	9		

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1920 April							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	1 12;	8 10;	22 5;	29 3				
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.3	2 10;	10 20;	19 7;	27 17				
SS Librae	15 43.4	—15 14	9.3—11.5	0 18.4	2 6;	9 22;	17 14;	25 6				
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	4 13;	11 21;	19 5;	26 13				
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	7 18;	16 1;	24 7					
R Arae	31.1	—56 48	6.8— 7.9	4 10.2	9 2;	17 22;	26 18					
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	4 0;	13 16;	24 8					
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	5 7;	12 0;	18 22;	25 17				
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	8 1;	16 10;	24 19					
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	1 16;	7 20;	20 4;	26 7				
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	4 15;	10 19;	23 4;	29 8				
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	4 7;	11 16;	19 1;	26 10				
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	7 1;	15 6;	23 10					
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	7 11;	15 0;	22 12;	30 1				
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	3 2;	10 20;	18 13;	26 7				
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	2 10;	10 10;	18 9;	26 9				
WX Sagittae	53.6	—17 24	9.2—10.8	2 03.1	2 2;	11 10;	19 22;	28 11				
WY Sagittae	17 54.9	—23 1	9.5—10.6	4 16.0	7 12;	16 20;	26 4					
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1		10 21;	21 5					
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	4 23;	12 5;	19 11;	26 17				
V Serpentis	11.1	—15 34	9.5—11.1	3 10.9	6 9;	13 7;	20 5;	27 3				
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	8 17		23 20					
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	2 10;	9 14;	16 18;	23 22				
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	5 18;	12 20;	19 23;	27 2				
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	2 22;	11 6;	19 13;	27 20				
RR Draconis	40.8	+62 34	9.3—13	2 19.9	4 21;	13 9;	21 21;	30 8				
RS Scuti	43.7	—10 21	9.3—10.3	0 15.9	4 23;	11 15;	18 6;	24 21				
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	3 19;	16 17;	29 15					
U Scuti	18 48.9	—12 44	9.1— 9.6	0 22.9	7 10;	15 1;	22 16					
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	5 21;	13 11;	21 1;	28 14				
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	2 3;	9 8;	16 13;	23 17				
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	9 1;	17 23;	26 22					
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	2 16;	9 10;	22 23;	29 17				
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	3 14;	10 22;	18 7;	25 16				
TT Lyrae	24.3	+41 30	9.4—11.6	5 05.8	2 21;	8 3;	18 14;	29 2				
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	1 13;	8 1;	21 3;	27 15				
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	2 0;	8 1;	20 1;	26 1				
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	4 1;	10 16;	17 7;	23 23				
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	4 6;	13 10;	22 13					
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	3 11;	11 21;	20 8;	28 18				
RW Capric.	12.2	—17 59	8.8—10.6	3 09.4	3 8;	10 3;	16 22;	23 17				
UW Cygni	19.6	+42 55	10.5—13	3 10.8	1 7;	8 5;	22 0;	28 21				
V Vulpec.	32.3	+26 15	8.2— 9.8	37 19.0	5 0							
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	2 23;	12 13;	22 4					
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	4 8;	13 13;	22 18					
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	7 5;	14 17;	22 5;	29 17				
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	1 12;	9 3;	16 17;	24 1				
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	3 14;	13 17;	23 19					
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	3 2;	10 12;	17 21;	25 6				
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	5 22;	15 14;	25 7					
RY Aquarii	14.8	—11 14	8.8—10.4	1 23.2	8 13;	16 10;	24 7					
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2 7;	12 11;	22 14					
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3			27 19					
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	1 10;	6 15;	17 0;	27 8				
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.4	1 16;	9 23;	18 6;	26 13				
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	3 18;	11 7;	18 19;	26 8				
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	6 12;	14 18;	23 0					

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1920. April							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7								
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	6 1;	14 4;	22 7;	30 10				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	1 17;	9 11;	17 5;	24 23				
RW Cassiop.	130.7	+57 15	8.9—11.0	14 19.2	5 3		19 22					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	2 16;	10 15;	18 13;	26 12				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	5 23;	13 18;	21 13;	29 8				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	2 14;	9 21;	17 4;	24 10				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	2		18					
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	3 17;	12 7;	20 21;	29 11				
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	12 2		23 5					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	4 15;	16 6;	27 21					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	2 16;	10 7;	17 23;	25 15				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	10 6		20 10					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	5 21;	13 14;	21 7;	29 1				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	1 4;	6 16;	17 17;	28 19				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	6 2;	13 16;	21 5;	29 19				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3			22 10					
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	7 13;	15 1;	22 11;	29 22				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	7 2;	14 6;	21 12;	29 17				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	2 6;	10 4;	18 2;	26 1				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	4 1;	14 4;	24 8					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		15 8						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	2 2;	10 1;	18 0;	25 22				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	3 4;	9 21;	16 13;	23 6				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	2 16;	11 23;	21 5					
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	2 5;	10 23;	19 16;	28 10				
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0		12						
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	2 20;	9 15;	23 5;	30 0				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	3 1;	9 16;	22 21;	29 11				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	1 19;	11 11;	21 2					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	2 4;	10 4;	18 3;	26 2				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	5 6;	12 0;	18 18;	25 11				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	4 3;	9 23;	21 14;	27 10				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	3 5;	7 21;	17 6;	26 15				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5		16 21						
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	6 20;	15 0;	23 5					
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	2 23;	10 0;	17 0;	24 1				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	6 7;	14 12;	22 17					
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	5 9;	10 21;	21 20;	27 8				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	8 11;	16 1;	23 14;	31 3				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	2 12;	9 22;	17 8;	24 17				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	2 3;	8 21;	22 11;	29 5				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	6 9;	12 18;	25 10;	31 18				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	6 20;	16 14;	26 8					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	6 8;	15 5;	24 1					
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	6 22;	13 0;	19 1;	25 3				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	2 7;	9 7;	23 8;	30 8				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		10 1;	27 4					
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	5 18;	13 8;	20 22;	29 12				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	5 11;	11 6;	22 19;	28 14				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	6 17;	13 11;	20 4;	26 23				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	7 0;	17 8;	27 16					
Y Lyrae	34 2	+43 52	11.3—12.3	0 12.1	4 22;	10 23;	23 1;	30 1				
RZ Lyrae	18 39.9	+32 42	9.9—11.2	0 12.3	4 19;	10 22;	22 4;	29 8				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1920. April							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	6 19;	12 18;	24 15;	30 14				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	5 19;	14 21;	24 0					
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	5 0;	12 1;	19 1;	26 2				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	6 20;	13 20;	20 20;	27 20				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	4 16;	12 16;	20 15;	27 15				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	2 1;	9 18;	17 10;	25 3				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	4 20;	12 0;	19 4;	26 8				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	4 0;	12 9;	20 18;	29 3				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	3 4;	9 11;	22 3;	28 11				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3		15 14						
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	4 8;	8 19;	17 16;	26 13				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	5 7;	12 18;	18 18;	25 12				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	1 10;	8 3;	21 13;	28 7				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	2 22;	17 15						
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	10 13;	15 10;	23 7;	30 4				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	6 14;	13 12;	20 9;	27 6				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	1 14;	11 8;	21 1;	30 18				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	1 23;	10 15;	19 6;	27 22				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	3 23;	8 22;	19 16;	30 9				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	9 21;	20 18						
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	5 7;	11 17;	24 13;	30 23				
V Lacertae	44.5	+55 48	8.5— 9.5	4 23.6	2 13;	12 13;	22 12;	27 11				
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.7	3 8;	8 18;	19 16;	30 13				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	1 21;	12 18;	23 15;	29 2				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	5 11;	11 18;	24 8;	30 15				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	3 6;	15 9;	27 12					
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.9	2 21;	9 21;	22 20;	30 19				

NOTES FOR OBSERVERS.

Monthly Report of American Association of Variable Star Observers, Dec. 20, 1919-Jan. 20, 1920.

SS Cygni, 213843, was at maximum on January 10, some twenty days later than predicted. SS Aurigae was due to rise on or about January 10, but as yet (Jan. 29), it is still faint. It is quite uncertain as to when these stars will again rise, and a close watch should be kept on both, especially SS Cygni which is difficult to observe now on account of being so near the Sun.

The Association is greatly indebted to Dr. Harlow Shapley and Mr. A. C. Perry for valuable additions to our slide collection, which has been in constant demand by the members ever since the catalogue was published. Mr. C. E. Barnes is preparing a new edition of the Constitution and List of Members for distribution to all the members. The reprints of the 1919 reports should now be in the hands of all our members, and those failing to receive a copy should advise the Recording Secretary.

Variable Star Observations, January, 1920.

Dec. 0 = 2422293 Jan. 0 = 2422324 Feb. 0 = 2422355

001046 X Androm.

J.D.	Est.	Obs.
242		
2334.6	10.6	M
35.6	10.7	V

001726 T Androm.

2315.6	<10.0	Jd
34.6	<12.6	Do

001755 T Cassiop.

2334.6	7.5	M

001838 R Androm.

2312.6	9.2	V
15.6	8.9	Hu
33.6	9.6	Pt
34.6	9.6	Do
34.6	9.6	M
35.6	9.5	V

***001909* S Ceti**

2281.1	<11.5	Ch

004047 U Cassiop.

2334.6	<12.8	Y

004958 W Cassiop.

2315.6	9.0	Hu
34.6	9.0	M

011208 S Piscium.

2341.5	<13.6	Jk

011712 U Piscium

2321.6	<12.3	Hu

012350 RZ Persei

2334.6	12.7	Y

012502 R Piscium

2341.6	<13.1	Jk

013238 RU Androm.

2334.6	<11.6	M

013338 Y Androm.

2334.6	8.7	M

014958 X Cassiop.

J.D.	Est.	Obs.
242		
2334.6	11.1	M

015354 U Persei

2321.6	10.0	Hu
34.6	10.6	M

021281 Z Cephei

2335.6	10.5	V
41.5	11.1	Do

021403 o Ceti

2317.0	8.3	Mu_3
17.5	8.1	Pt
32.1	8.5	Mu_2
36.5	8.6	Ya
39.1	8.7	Mu_2

022150 RR Persei

2260.6	12.2	Yo
2322.5	8.7	Y
34.6	9.2	

***022813* U Ceti**

2282.2	11.0	Ch

023133 R Trianguli

2260.6	6.1	Yo

024356 W Persei

2333.6	9.6	Pt

030514 U Arietis

2339.5	13.	Y

032043 Y Persei

2337.7	9.8	Pt

041619 T Tauri

2334.5	9.6	M

042209 R Tauri

2334.5	9.3	M
37.7	9.5	Pt

042215 W Tauri

J.D.	Est.	Obs.
242		
2260.6	10.4	Yo
77.6	9.8	
2307.5	10.5	V
21.5	10.4	Yo
34.5	10.8	M
34.6	10.3	Cl
35.7	10.7	V
36.5	10.2	Y
37.7	10.8	Pt

042309 S Tauri

2334.5	<12.3	M

043274 X Camelop.

2336.6	10.3	Y

045307 R Orionis

2336.5	12.6	Y
36.6	12.0	Jk

050003 V Orionis

2336.5	<12.7	Y

***050022* T Leporis**

2321.5	8.7	Yo

050953 R Aurigae

2335.5	10.4	M
35.6	10.1	V
42.5	9.6	Ya

052034 S Aurigae

2339.6	9.0	Ya

***052404* S Orionis**

2334.5	11.6	M
45.6	11.1	E

***053005a* T Orionis**

2334.5	11.0	M

053326 RR Tauri

2345.6	<12.4	E

053531 U Aurigae

J.D.	Est.	Obs.
242		
2322.5	10.7	Y
35.6	9.5	V
36.5	9.2	Y
42.6	9.2	Ya
45.6	9.1	E

054319 SU Tauri

2312.6	9.5	V
21.6	9.5	E
22.5	9.5	Y
34.5	9.3	Cl
35.6	9.4	V
36.5	9.5	E
36.5	9.4	Y
36.6	9.8	Jd
42.8	9.5	E
45.6	9.5	

054615a Z Tauri

2336.5	13.	Y
45.6	13.5	E

054615b RS Tauri

2336.5	9.3	Y
45.6	9.0	E

054615c RU Tauri

2336.5	13.	Y
45.6	13.5	E

054920 U Orionis

2312.6	11.1	Pt
45.6	11.8	E

054974 V Camel.

2334.6	<12.8	Y

055353 Z Aurigae

2321.5		Yo
35.6	10.7	M
42.6	10.9	Ya
45.7	10.2	E

060450 X Aurigae

2337.6	9.2	Pt
39.5	9.1	Ya
45.7	9.5	E

060547 SS Aurigae

J.D.	Est.	Obs.
242		
2291.8	<10.8	Hy
2312.6	<10.8	V
14.5	<12.0	Cl
17.7	<13.0	Hy
18.5	<12.6	Cl
21.6	<13.0	E
22.5	<13.3	Y
22.5	<12.0	Cl
22.7	<10.8	Jd
34.5	<12.4	M
34.5	<12.4	Cl
34.6	<13.3	Y
35.6	<11.4	V
36.5	<13.3	Y
36.6	<12.4	Jd
38.5	<13.0	Jk
39.5	<13.3	E
39.5	<13.3	Y
41.6	<13.0	Jk
42.8	<13.3	E
45.6	<13.0	E

063159 U Lyncis

2334.6	13.	Y

065111 Y Monoc.

2334.6	<13.3	Y

***065208* X Monoc.**

2339.6	8.4	Ya

065355 R Lyncis

2334.6	11.9	Y

070122a R Gemin.

2286.2	7.0	Ch
2321.6	7.9	Hu
35.6	8.7	M
36.6	9.0	Jd
36.6	8.8	E
37.6	8.9	Pt
38.6	8.6	Jd

070122b Z Gemin.

2235.6	<11.6	M
37.6	11.7	Pt

070122c TW Gemin.

2335.6	8.4	M

070310 R Can. Min.

2336.6	9.0	Jd
36.6	9.3	E

VARIABLE STAR OBSERVATIONS, January, 1920—Continued.

072708
S Can. Min.

J.D.	Est.	Obs.
242		
2282.2	9.7	Ch
2334.5	9.9	Cl

073508
U Can. Min.

2354.6	13.1	Y

074323
T Gemin.

2335.6	<11.5	V

074922
U Gemin.

2291.8	<12.3	Hy
2314.5	<12.5	Cl
17.7	<13.3	Hy
21.5	<12.5	Yo
22.5	<11.9	Cl
34.5	<12.3	M
34.6	<13.3	Y
35.6	<11.7	V
38.6	<13.3	Jk
39.7	<13.3	Hy
39.7	<13.7	E
42.8	<13.3	E
45.6	<13.3	E

081112
R Cancri

2334.6	9.7	Cl
37.7	8.9	Pt
39.6	8.7	Ya

083019
U Cancri

2335.6	10.5	V

084803
S Hydrae

2335.7	8.2	Pt

085008
T Hydrae

2335.7	9.0	Pt
36.6	9.0	E
36.6	9.2	Jd

090425
W Cancri

2335.6	<11.7	V

093178
Y Draconis

2334.6	10.8	Y

093934
R Leonis Min.

2435.7	7.9	Pt
39.6	7.5	Ya

094211
R Leonis

J.D.	Est.	Obs.
242		
2335.6	9.5	Pt
36.6	9.2	Jd
36.6	9.3	E

103769
R Ursae Maj.

2317.6	9.5	Pt
25.8	8.5	M

123160
T Ursae Maj.

2325.8	9.3	M
35.7	10.0	Pt
38.6	10.6	Jk
39.5	11.0	Do

S Urs. Maj. 123961

2325.8	11.0	M
35.7	12.0	Pt
38.6	12.1	Jk
39.5	12.0	Do

134440
R Canum Ven.

2325.8	<11.2	M

142539
V Bootis

2325.8	8.5	M

153378
S Ursae Min.

2307.5	8.8	V

154428
R Cor. Bor.

2317.9	6.1	Pt
25.8	6.2	M

163137
W Herculis

2322.5	8.5	Y

163172
R Ursae Min.

2334.5	11.6	Cl

163266
R Draconis

2322.5	12.5	Y
41.5	11.8	Jk

165631
RV Herculis

2338.9	12.0	E

175458a
T Draconis

2341.5	12.0	Jk

175458b
UY Draconis

2341.5	10.8	Jk

180565
W Draconis

J.D.	Est.	Obs.
242		
2339.6	<13	Jk

180911
Nova Ophiuch No. 4

2307.5	8.9	V

184205
R Scuti

2312.5	5.5	Pt

184300
Nova Aquilae No. 3

2280.2	>8.0	Ch
12.5	7.7	P

190925
S Lyrae

2336.5	<11.6	Do

191637
U Lyrae

2337.5	11.1	Pt

193449
R Cygni

2267.1	10.5	Ch
84.2	10.9	Ch
2307.5	9.8	V
17.5	9.5	Pt
35.5	8.7	V

194048
RT Cygni

2284.2	9.2	Ch
2335.5	7.9	V
37.6	7.5	Pt

194348
TU Cygni

2335.5	<11.2	V

194632
χ Cygni

2336.5	<12.4	Do

195849
Z Cygn

2317.5	12.6	Pt

200647
SV Cygn

2291.8	7.7	Hy
2313.6	8.4	Ya

201130
SX Cygni

2322.5	8.3	Y
34.5	9.5	Y

201647
U Cygni

J.D.	Est.	Obs.
242		
2291.8	7.0	Hy
2317.5	7.8	Pt
25.7	8.6	Jd
34.5	7.8	Ya

202946
SZ Cygni

2313.6	9.6	Ya

202954
ST Cygni

2334.5	13.3	Y

203226
V Vulpec.

2317.5	9.1	Pt

203816
S Delphini

2307.5	10.4	V
34.5	10.3	Cl

205923
R Vulpec.

2317.5	9.3	Pt

210129
TW Cygni

2322.5	12.5	Y
34.5	12.4	Y

210868
T Cephei

2315.6	7.0	Hu
17.6	8.1	Pt
34.6	7.7	Ya

211614
X Pegasi

1324.5	11.0	Y

213678
S Cephei

2315.6	9.0	Hu

213753
RU Cygni

2315.6	8.9	Ya

213843
SS Cygni

2280.2	< 9.6	Ch
91.8	11.7	Hy
2307.5	<11.3	V
12.6	11.9	Pt
14.5	12.1	Cl
17.5	12.0	Pt
18.5	12.1	Cl
21.5	11.9	Pt
21.6	11.5	E
22.5	12.0	Cl
22.5	11.6	Y

SS Cygni

J.D.	Est.	Obs.
242		
25.5	<11.3	Y
25.6	<10.9	Jd
26.5	<11.3	Y
29.5	11.8	Cl
29.5	11.9	Pt
33.6	8.5	P
34.5	8.4	Y
34.5	8.3	M
34.5	8.3	Cl
34.6	8.2	Do
35.5	8.4	M
35.5	8.7	V
35.6	8.5	Pt
36.5	8.4	Pt
37.5	8.5	Pt
39.5	8.6	E
41.5	8.4	Jk

225914
RW Pegasi

2334.5	10.2	Y
35.5	10.1	V

230110
R Pegasi

2334.5	9.0	Y
37.5	8.4	Pt

230759
V Cassiop.

2315.6	11.2	Hu
17.6	11.3	Pt

231425
W Pegasi

2315.6	10.0	Hu

232848
Z Androm.

2334.6	9.0	Do

233335
ST Androm.

2315.6	9.0	Hu
34.6	9.2	Do
37.7	9.1	Pt

233815
R Aquarii

2337.5	7.3	Pt

235855
Y Cassiop

2335.6	<11.0	

235939
SV Androm.

2315.6	8.1	Hu
34.5	8.5	Y
37.7	8.6	Pt
39.6	8.4	Jk

No. of Observations: 275; No. of Stars Observed: 114; No. of Observers: 15.

We welcome observations this month from a new member from a distant land, Mr. R. G. Chandra, of India, (Ch). Our Secretary, Mr. Olcott, is spending the season in South Carolina. Rev. T. C. H. Bouton has gone to Florida, where he expects to resume his observing with his smaller telescope. Mr. Hunter's list is the last we expect to receive for several months as he starts soon on a journey through South America. Miss A. S. Young has recently joined the ranks of Life Members. Misses Woods and Mackie are to be congratulated for their recent contributions to our knowledge of Novae by the discovery of Nova Ophiuchi No. 5 and Nova Lyrae No. 1.

The following observers contributed to this report: Messrs. Chandra, Clement, Eaton, Hay, Hunter, Jordan, McAteer, Mundt, Peltier, Vrooman, Yalden, and Yont, and Misses Downer, Jenkins, and Young.

HOWARD O. EATON,
Recording Secretary.

Observations of Nova Aquilae.

Date 1918	C.S.T. (summer)	Comparisons. M.
June 11	11:00 P. M.	0.4; brighter than Altair.
12	10:45 P. M. to 11:30 P. M.	0.4; $v <$ Vega.
14	10:35 P. M.	Not as bright as Vega.
15	11:30 P. M.	Not as bright as α Cygni; brighter than α Ophiuchi.
17	10:30 P. M.	2.2; equal to γ Cygni.
21	11:00 P. M.	2.8; equal to γ Aquila.
26	11:00 P. M.	3.4; equal to η Serpentis.
27	11:00 P. M.	3.4; equal to η Serpentis.
30	10:15 P. M.	3.4; equal to δ Aquila.
July 1	10:30 P. M.	3.2; brighter than η Serpentis.
2	11:00 P. M.	3.2; brighter than η Serpentis.
4	10:30 P. M.	3.0; trace brighter.
5	1:30 A. M.	3.0; trace brighter.
8	10:30 P. M.	3.4; same as η Serpentis.
9	11:00 P. M.	3.4; same as η Serpentis.
10	11:15 P. M.	3.8; fainter than η Serpentis.
15	10:30 P. M.	3.6; same as λ Aquila.
17	10:30 P. M.	3.6; same as λ Aquila.
30	10:30 P. M.	4.5; same as θ Serpentis.
31	11:00 P. M.	4.5; same as θ Serpentis.
Aug. 13	11:00 P. M.	4.8; fainter than θ Serpentis.
25	10:00 P. M.	4.5; brighter than the 5th mag. star near.

DAVID E. HADDEN.

Alta, Iowa.

COMET AND ASTEROID NOTES.

Comas Solà's Asteroid.—From European publications we learn that this object was first announced by Comas Solá as a planet. Just who was guilty of attaching the name of comet to it we have not learned. The planet is growing fainter and is picked up with difficulty without a photograph of its region. According to the ephemeris given below it is slowing up its retrograde motion and during March will probably move southeastward from Gemini into Cancer.

Elements of Comas Solá's Asteroid.—A telegram from Professor A. O. Leuschner, Director of the Students' Observatory, Berkeley, California, gives the following elliptical orbit, and ephemeris of Comas Solá's object, as computed by Messrs. Einarsson and Jeffers from observations on January 20, 24, and 26.

ELEMENTS

Time of perihelion passage	(T)	= 1920, March 16.36 G.M.T.
Perihelion minus node	(ω)	= 194° 28′
Longitude of node	(Ω)	= 300° 00′
Inclination	(i)	= 17° 59′
Perihelion distance	(q)	= 2.326
Eccentricity	(e)	= 0.1109
Periodic time	(P)	= 4.23 years

EPHEMERIS

G.M.T.		R.A. h m s	Dec. ° ′	Light
1920, February	4.5	7 40 37	+20 7	1.00
	12.5	7 33 28	+19 14	
	20.5	7 28 20	+18 23	
	28.5	7 25 27	+17 33	0.80

The elements are uncertain. They represent Barnard's observation of January 29, R.A. —5″, Dec. —9″.

S. I. BAILEY.

Harvard College Observatory Bulletin 711.
Cambridge, Mass., U. S. A., February 4, 1920.

Circular Elements of Comas Solá's New Asteroid:—I am sending circular elements for the Comas Solá object, which is evidently not a comet but an asteriod, as suspected by other observers.

From observations of January 13 and January 24, as follows:

Date G.M.T.	R.A.	Dec.	Observer
Jan. 13.5011	$8^h\ 6^m\ 44^s$	22° 23′ 0″	Comas Solá (reported by Lecointe)
Jan. 24.8240	$7^h\ 52^m\ 35^s.8$	21° 15′ 8″	Barnard, Yerkes Observatory

I have computed the following circular elements.

EPOCH, 1920, JANUARY 20.0, G.M.T.

Argument of latitude	= 178° 35′ 16″	1920.0
Ω	= 299° 12′ 14″	1920.0
i	= 29° 43′ 48″	1920.0
μ	= 739″.916	
log a	= 0.45389	
Period	= 1751.54 days	

R. F. ROSSITER.

Detroit Observatory, Ann Arbor, Mich., Feb. 5, 1920.

Discovery of Comet *d* 1919 (Finlay-Sasaki).—A letter has been received from Professor Issei Yamamoto, of the Observatory of the Kyoto Imperial University, Kyoto, Japan, giving the particulars of the re-discovery of Finlay's Comet by Mr. T. Sasaki on October 25, 1919. The comet was first seen

with a 4-inch equatorial, but for want of measuring instruments its position could not be determined with accuracy. Visual sketches of the field by Dr. Kudara and Mr. Sasaki afforded means of determining the approximate position. Photographs were made later by Professor Yamamoto with a 7-inch doublet, but in the absence of measuring apparatus they were not available for accurate determinations of position.

Harvard College Observatory Bulletin 713.
Cambridge, Mass., U. S. A., February 13, 1920.

Elements of Comas Solà's New Asteroid.— Mr. F. E. Seagrave sends the following preliminary elements of the new asteroid computed by himself from observations by Barnard on January 21, 24 and 29. On January 28, 1920, the asteroid was right on the ecliptic at its descending node ($\lambda = 120° 32'$).

ELEMENTS.

Epoch 1920, January 24.8241

M	= 347°	54′	28″	log a	= 0.41554
ω	= 195	04	14	log q	= 0.35668
Ω	= 300	05	09	log e	= 9.10295
i	= 17	13	17	μ	= 844″.70

The Asteroid (588) Achilles.— The following ephemeris of the planetoid (588) Achilles has been computed by Miss Julie Marie Vinter-Hansen, of the Copenhagen Observatory. The asteroid is one of the four whose distance is about the same as that of Jupiter, so that observations of it are very important. Its magnitude is only 14.8, so that large photographic telescopes will be required for its detection.

EPHEMERIS OF ASTEROID (588) ACHILLES.
(12^h Gr. M. T.)

		True α			True δ		log Δ	Br.
		h	m	s	°	′		
1920								
Mar.	27	13	35	15	— 22	27.4	0.6699	
	31		33	19	22	21.9		
Apr.	4		31	20	22	15.1	0.6666	
	8		29	19	22	07.2		
	12		27	15	21	58.4	0.6651	
	16		25	11	21	48.6		
	20		23	09	21	38.1	0.6653	
	24		21	09	21	26.9		
	28		19	14	21	15.2	0.6674	
May	2		17	23	21	03.1		
	6		15	38	20	50.8	0.6712	
	10		14	01	20	38.5		
	14		12	31	20	26.2	0.6765	
	18		11	10	20	14.1		
	22		09	59	20	02.3	0.6832	
	26		08	58	19	51.1		
	30		08	07	19	40.4	0.6911	
June	3		07	27	19	30.3		
	7	13	06	58	— 19	21.1	0.6999	

Opposition 1920 April 13. Magnitude = 14^m.8.

COMMUNICATIONS.

An Amateur's Observatory.—In June, 1918, I purchased a 4-inch astronomical telescope equatorially mounted on a tripod, with circles. I found it very unhandy to use this instrument set up in the open air, with the wind making it tremble more or less. I had been for several years using a field glass, but when snow and cold weather came during the winter months a great damper was placed on my desire for celestial observations out in the open. So I determined to build some kind of an observatory so that I could enjoy the use

Mr. Carrington's Observatory.

of my more powerful, as well as much more costly, telescope. I had read in G. F. Chambers' "Hand Book of Astronomy" complete descriptions of building observatories for amateurs, with the cost, etc., in England. Thinking that it would be of interest to some of your readers, who like myself are amateurs, I am enclosing you a photograph with the following description of the observatory which I built in the fall of 1918. I selected a corner away from other buildings, where I have a clear horizon on three sides,—the north side is somewhat hamp-

ered with trees. In the center of where the foundation was to be placed a hole was dug two feet deep and about the same square; this was filled with stone and concrete. A circular board frame was placed around this, three feet high. This frame was nine feet and four inches in diameter. Concrete and stone was built up inside of this to make a wall from six to eight inches thick. The space inside this wall was filled with loose stone to within six inches of the top. The center was carried up from the ground with concrete and stone. All was now levelled off to the top of the board frame with concrete, making a smooth floor. As soon as this foundation was sufficiently cured, the frame, held together with wire hoops, was removed. On the top of this a circular wall six feet high was built of hollow vitrified or glazed silo tiles, and on top of this wall, which was carefully levelled, ordinary spikes projected from the masonry two and one-half inches, to hold the plate which was to form the track for the revolving roof. This plate was made like a large circular wheel with felloes sawed out of two-inch yellow pine plank, on the top of which were solidly nailed similar felloes of one-inch fir, being careful to break the joints so as to hold the plate together, which was now three inches thick. Three-quarter inch strips were now sawed part way through so that they could be bent around and firmly nailed on the top of the plate, leaving a space between them two inches wide. Another plate was now constructed, exactly as the one just described, and to fit on the top of it. On the under side of this were screwed six two-inch truck castors at equal distances apart. Thse castors run around in the hollow space above described. On the upper side of the last plate straight rafters of light material, about six feet long, are placed two feet apart, coming together in the center; on these are nailed light ceiling boards and the whole covered with asphalt rubberoid roofing. There is an opening left between two rafters, over which a shutter opens and closes on hinges; by an arrangement of sash-cord and pulleys this shutter can be operated from the floor of the observatory. The telescope is mounted on a solid concrete column, reinforced and obelisk shaped. There are some hardwood pieces fixed in the concrete on top of this column, but capable of a circular motion so as to allow the proper and accurate adjustment of the telescope.

The total cost of the observatory to me did not exceed $75.00, all the work being done by myself with the assistance of a neighbor farmer (Mr. H. L. Felter, who reports the weather conditions here). The only part of the work paid for was the laying of the tile; this cost $8.00. By means of two double tent pulleys and some sash-cord I can stand at the eye-piece of the telescope and revolve the roof with one hand in either direction. I have now used my observatory for more than a year, and for convenience, comfort and being always ready for observation, it is worth to me more than it cost.

I first set up my telescope on the forenoon of June 8, 1918, intending to observe the solar eclipse in the afternoon, but so far as the telescope was concerned I was disappointed for I broke the sunglass first peep, and this although I had stopped the objective down to two inches. However, I was more than repaid later on. The seeing that evening and night was fine and I remained out until long after midnight, testing my new instrument and drinking in the grand sights. Saturn and Mars were in the western sky. About 11:00 o'clock I turned to the southeast, and there blazing in Aquila shone the Nova. I knew at a glance that it was a stranger but did not know exactly of what nature.

I was certain the star had not been there many evenings, but there it was, fully as bright as Vega or Arcturus, brighter than Altair or Spica. When I turned the telescope upon it, it fairly burned and sparkled with a bluish light. I watched it for more than an hour. On Monday I wrote Mr. Hadden of Alta, and he wrote me that it was a new star that had first been seen on the evening of the 8th. Had it not been for my new telescope, I probably should not have been a discoverer. I am enclosing you my notes as I observed the Nova up to June 27:

OBSERVATIONS OF NOVA AQUILAE.

1918 June 8	Very bright blue; 1st mag.; sparkled in telescope.
9	Very bright blue; brighter than 1st mag.
11	Very bright blue; brighter than 1st mag.
14	Waned a little, but sparkled in telescope.
15	Waned to about 1st mag.
16	Waned a little; less than 1st mag.
17	A little less than 1st mag.
18	Waning; losing light.
19	Waning; losing light.
21	Very red; a little above 2nd mag.; moon; bad seeing.
26	Red; dim; 4th mag.
27	Red; dim; about 4.5 mag.

FRED S. CARRINGTON.

Washta, Iowa.

Planetary Rotation.—In the 1919, December number of "POPULAR ASTRONOMY", there appears a communication from Mr. John W. Barr of Cincinnati, entitled, "Does an unknown Force Perpetuate Diurnal Rotation?" Having seen no comment on it in the January number, I venture to say that, although I do not believe it possible to completely disprove his hypothesis that such an (X) force exists, it is improbable; moreover, the fact that Mercury and Venus have no diurnal rotation, and the rest of the planets have, proves nothing.

He divides the planets into these two classes: those having diurnal rotation and those without; and he notices that satellites and diurnal rotation go together. Let us take as an example, then, the planet Jupiter, which has four satellites as large as the Moon and five smaller ones. The tidal forces due to the Sun and the satellites, however, are negligible, the Sun's tide-producing force on Jupiter being only 1/125 (approximately) of the Sun's tidal force on the Earth. Besides this, the mass of Jupiter is so great that a force many times greater than that acting on the Earth would be needed to produce a change of rotation period equal to a change in the diurnal rotation of the Earth. Considering the three planets beyond Jupiter, the same argument applies.

As for Mars, its satellites are too small to produce much change, and the tidal force of the Sun is less than 1/3 of its tidal force at the distance of the Earth. According to Professor W. H. Pickering, "Apparently the only inexplicably long period of rotation in the solar system is that of the planet Mars." (POPULAR ASTRONOMY, Oct. 1919.)

In the case of Mercury, the Sun's tidal force is 6 or 7 times as great as the combined effect of the Sun and Moon on the Earth, and Mercury's mass is small. At Venus, the Sun's tide-producing force is 2¼ times its tide-producing force on

the Earth, but the combined effect of the Sun and Moon is somewhat greater than this. But if we accept Pickering's view (Pop. Ast. Oct. 1919) that the Moon was only a meteoric ring before the Cretaceous Period, we have a demonstration that the rotation period of the Earth should be shorter than that of Venus, as it actually is, and by applying the law governing the tides, the law of inverse cubes, the demonstration is made for the other planets.

Dean B. McLaughlin.

513 Hoover Ave., Ann Arbor, Mich., Jan. 13, 1920.

GENERAL NOTES.

Professor E. W. Brown, of Yale University, has been awarded the Bruce Gold Medal of the Astronomical Society of the Pacific. An invitation has been extended to Professor Brown to attend the March meeting of the Society and receive the medal in person.

Dr. V. M. Slipher, director of the Lowell Observatory, has been awarded the Lalande Prize of the Paris Academy of Sciences.

Professor A. S. Eddington, of the Greenwich Observatory, has received the de Pontecoulant Prize of the Paris Academy of Sciences.

Dr. W. W. Campbell, director of the Lick Observatory, has been elected to honorary membership in the Royal Institution of Great Britain. This is an honor held by but two other astronomers, Dr. George E. Hale and M. Henri Deslandres.

Mr. C. C. Wylie, of the U. S. Naval Observatory, has accepted a position in the University of Illinois Observatory.

M. G. Bigourdan, of the Paris Observatory, has been awarded the Janssen Prize for this year, especially on account of his studies of the Nebulæ.

C. A. de Campos Rodrigues, vice admiral, hydrographer, director of the Observatory of Lisbon, active member of the Academy of Sciences of Lisbon, died at Lisbon on December 25, 1919, after a short illness, aged 83 years.

Parallax of Nova Aquilae No. 3.—In the Publications of the Astronomical Society of the Pacific, No. 185, Mr. A. van Maanen gives the parallax of the nova from measures of 16 exposures as

$$\pi = +0''.019 \pm 0''.006 .$$

The absolute parallax is $+0''.021$ and the absolute magnitude in the vicinity of -4.9 at maximum and $+7.1$ at minimum.

Parallax of Cepheid Variables.—In the same number of the Publications of the A. S. P., Mr. van Maanen gives the average parallax of the seven Cepheid Variables for which trigonometric parallaxes have been determined as +0″.011, which agrees quite perfectly with that derived by Shapley, 0″.008, from the period-luminosity curve.

Nova Lyrae and o Ceti.—A telegram from the Mount Wilson Observatory, California, states that spectroscopic observations of Miss Mackie's Nova Lyrae by Adams and Joy show broad bright hydrogen and other bands, with a trace of the chief nebular line. The hydrogen absorption lines were double, with a displacement of about 15 and 30 Ångströms toward the violet. The spectrum of o Ceti shows remarkable changes. Bright helium lines are present. Hydrogen lines are stronger, greatly widened, and displaced toward the red 100 kilometers with reference to narrow bright lines.

Harvard College Observatory Bulletin 713.
Cambridge, Mass., U. S. A., February 13, 1920.

Changes of Ground Level in Crete.—In the course of a discussion on the subject of Crete at the Royal Geographical Society, Professor J. L. Myres described the remarkable changes of ground level that have occurred there since classical times. The whole island has swung upon an axis, the eastern half sinking and the western half rising, so that whereas at Hierapetras and Spinalonga the ancient quays and harbor works are now under water, the little Greek harbor of Phalasarna, at the west end of the island, is now totally upheaved, so that one can walk about on the floor of the ancient harbor, upraised and dry. (*Scientific American*, February 14, 1920.)

Another New Star.—Miss Woods has found another Nova. Its position is, R. A. $16^h\ 48^m\ 24^s$, Dec. $-29°\ 27'.8$ (1900). A star of about the twelfth magnitude follows 1″.1 south 7″, whose image on plates of small scale is obscured by that of the Nova, when the latter is bright. The New Star is invisible on photographs taken previous to April, 1917, some of which show to the seventeenth magnitude. It does not appear on a plate made April 18, but was of magnitude 6.5 on April 25, 1917. Large fluctuations in light occurred until August of the same year. The Nova has not been found on recent plates. It does not appear on a photograph taken June 13, 1919, which shows stars to magnitude 13.4. The determinations of magnitudes are by Miss Leavitt. No spectrum of this star has been obtained.

An endeavor is now being made to examine current plates soon after they are taken in order to obtain as complete a record as possible of these stars. Considerable delay, however, is inevitable at present in the case of the Arequipa plates of the southern sky. Also, since the recent plate is compared with an earlier photograph of the same region, it sometimes happens, as in this instance, that the Nova is found on the older plate, which hitherto had not been examined.

It may be worthy of note that the five new stars discovered within the last five months occur in the region of the Milky Way between R. A. $16^h\ 48^m$ and

$20^h\ 3^m$. This is not due to special attention given to this region, since the whole available portion of the Milky Way has been examined. The maximum magnitudes of the five stars, 7.2, 7, 7.5, 6.5, and 6.5 respectively are unexpectedly uniform.

S. I. Bailey.

Harvard College Observatory Bulletin 708.
Cambridge Mass., U. S. A., January 23, 1920.

Résumé of Sunspot Observations at Mt. Holyoke College, 1919.

Month	No. of Obs.	North of Equator No. Groups	North of Equator Av. Lat.	South of Equator No. Groups	South of Equator Av. Lat.	Av. No. at One Obs.	New Groups
Jan.	15	11	+17°1	13	— 8°6	4.20	24
Feb.	15	14	15.6	7	7.9	4.27	18
Mar.	17	10	12.8	10	11.2	4.06	17
Apr.	17	7	10.3	11	13.5	3.59	15
May	20	7	12.2	15	12.3	4.65	19
June	9	9	15.9	12	10.7	7.44	16
Sept.	8	4	9.4	9	12.1	4.00	13
Oct.	16	7	12.7	13	11.1	3.69	14
Nov.	13	10	13.1	5	16.0	2.85	12
Dec.	15	8	+12.6	8	—12.4	3.40	14
Total	145	87		103			162

Average number at one observation..... 4.11
Average latitude of groups north of equator.....+13°5
Average latitude of groups south of equator.....—11°2

The same method of observation was used as in previous years. We saw the sun free from spots on only one day, December 20. During the year eighteen groups were observed with an average latitude of less than five degrees, and of these, fourteen were south of the equator.

Louise F. Jenkins.

John Payson Williston Observatory.

New Bedford Astronomical Society.—The following program of lectures to be given before the New Bedford (Massachusetts) Astronomical Society shows that the society is very much alive.

"We are pleased to announce that a course of lectures has been arranged to be given in Library Lecture Hall on dates mentioned below. To these lectures you and your friends are cordially invited.

"Friday evening, January 30, Professor Frederick Slocum of Brown University, subject, Sunlight and Starlight. Professor Slocum needs no introduction to a New Bedford audience and those who have heard him will not require a second invitation for this lecture.

"Friday evening, February 27, Dr. Harlan True Stetson of Harvard College, subject (to be announced). Dr. Stetson is Director of the Students Astronomical Laboratory at Cambridge and those who heard his interesting lecture last winter on the application of Astronomy to Navigation will need no urging to hear him again.

"Friday evening, March 26, Rev. Joel H. Metcalf of Winchester, Mass.,

subject, Comets. Mr. Metcalf is a minister of the Unitarian Church but has done considerable work along astronomical lines, both in research work and the making of lenses. He is particularly interested in Comets and has discovered two during the past summer.

"All the lectures will be illustrated and will begin at 8:00 o'clock."

Eclipse Diagram of May 29, 1919.—The accompanying diagram has been reproduced from the December 1919 number of *L'Astronomie,* where it is used to illustrate an address given by Count A. de la Baume Pluvinel before

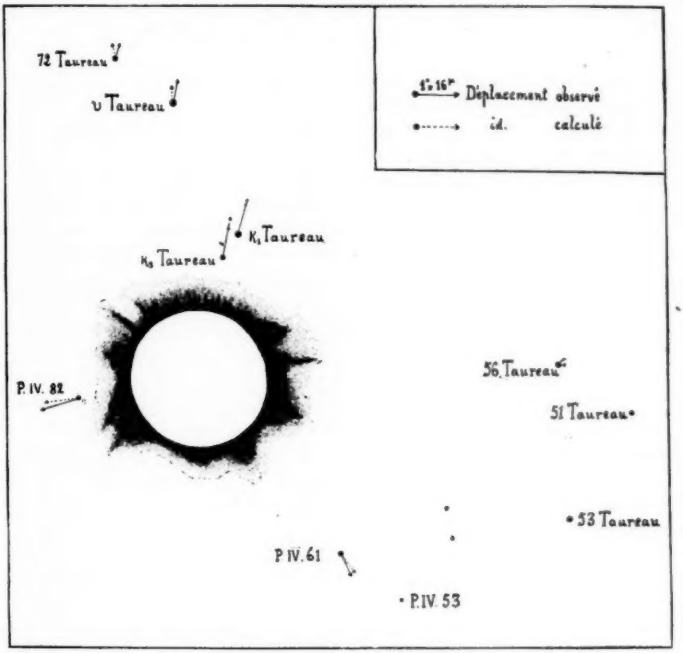


CHART OF STARS NEAR THE SUN DURING THE TOTAL ECLIPSE OF MAY 29, 1919, showing the observed displacements and those calculated according to the Einstein theory.

From *L'Astronomie,* December 1919.

the Société Astronomique de France on November 5 last. It will be of interest to our readers as showing graphically the positions and the displacements of the stars, which are said to have verified the Einstein theory. The stars are in the constellation Taurus, just north of the Hyades. The displacements indicated are greatly exaggerated in the diagram in order to make them readily visible.

Einstein on His Theory.—The following is a portion of a statement given by Dr. Albert Einstein to the London *Times* of November 28, 1919. It will be seen that he does not think, as some writers have indicated, that his theory overthrows in any real sense Newton's law of gravitation.

"In the generalised theory of relativity, the doctrine of space and time, kinematics, is no longer one of the absolute foundations of general physics. The geometrical states of bodies and the rates of clocks depend in the first place on their gravitational fields, which again are produced by the material systems concerned.

"Thus the new theory of gravitation diverges widely from that of Newton with respect to its basal principle. But in practical application the two agree so closely that it has been difficult to find cases in which the actual differences could be subjected to observation. As yet only the following have been suggested:—

"1. The distortion of the oval orbits of planets round the Sun (confirmed in the case of the planet Mercury).

"2. The deviation of light-rays in a gravitational field (confirmed by the English Solar Eclipse Expedition).

"3. The shifting of spectral lines towards the red end of the spectrum in the case of light coming to us from stars of appreciable mass (not yet confirmed).

"The great attraction of the theory is its logical consistency. If any deduction from it should prove untenable, it must be given up. A modification of it seems impossible without destruction of the whole.

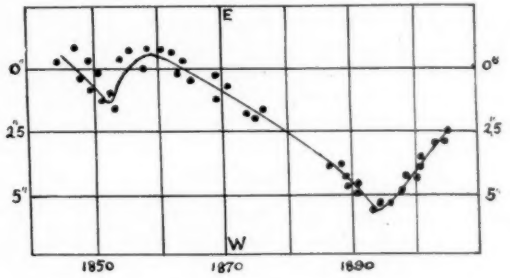
"No one must think that Newton's great creation can be overthrown in any real sense by this or by any other theory. His clear and wide ideas will forever retain their significance as the foundation on which our modern conceptions of physics have been built."

The Ultra-Neptunian Planet.—It was in the year 1846 that the existence of a new planet was announced from a purely mathematical analysis, and this has ever been justly regarded as a great triumph in Celestial Mechanics. As nearly every one knows, that there was a great, unseen world moving in an orbit far greater than that of Uranus was rendered certain by a study of the motion of the latter body along its path. By the year 1845, Uranus had gotten one hundred and thirty-three seconds ahead of where it should have been in the sky; evidently it must be disturbed in its motion by the pull of some world whose pull had not already been allowed for, and it was from an intricate mathematical study of the varying perturbations that the exact position of the disturbing body in the sky could be stated. The new body was looked for on the night of September 23, 1846, and within half an hour after the search began it was found in exact accordance with the prediction.

But during the seventy-five years which have elapsed since the discovery of Neptune, in which time Uranus has gone almost completely around its orbit, it has been found to be still apparently slightly disturbed in its motion. Sometimes it is slightly ahead of where it should be in the sky and sometimes behind, though the displacements are very much less than before the action of Neptune was allowed for. Thus at no part of its great path is the planet much more than five seconds from its predicted position, a very much smaller quantity than

the one hundred and thirty-three seconds with which Leverrier, the discoverer of Neptune, had to deal.

The smallness of this disturbance is doubtless due to the great distance away of the disturbing planet, but it makes the exact prediction of the direction of the new body very difficult. For the measures of the positions of Uranus cannot be made with perfect accuracy at the telescope, and the unavoidable errors of observation make the errors of theory somewhat uncertain.



DEVIATIONS OF URANUS IN LONGITUDE.

The figure shows the errors as they are determined from 1845 to 1905. Were the observations perfectly accurate all of the dots would lie exactly on a smooth curve. It will be noticed that in 1895 the planet was 5.2 seconds west of the place it should have occupied in the sky.

Several solutions of the problem have been carried through, though the results are somewhat uncertain. One of the latest indicates that the new body must move in a great orbit, nearly four thousand millions of miles from the sun, and that it occupies two hundred and eighty-three years in making the circuit of the heavens. Its mass is about six times that of the earth, so that it is much smaller than any of the four neighboring planets. According to this solution the new planet is now in the western borders of the constellation Gemini, in excellent position for observation.

At the great distance of the supposed body from the sun, it will receive but one seventeen-hundredth part as much sunlight as the earth does. In fact, as seen from this distant world, the sun would appear as a point of light—an intensely brilliant star. But though the sun would appear to have no disc, it would be nearly four hundred times as bright as the full moon. The inhabitants of this world, if there are any there, would by no means dwell in darkness.

The unknown body is also very far from the earth. When we consider its small mass and also its great distance both from the sun and from us, we see at once that even when viewed under the most favorable conditions it must appear very faint. In fact, it is believed that when discovered it will shine only as a star of the twelfth to the thirteenth magnitude, and thus only be visible in the larger telescopes.

Unfortunately, we have no complete charts showing nearly so faint stars as this. There has been published a great survey of the northern sky giving the positions of some 340,000 stars, but these only extend to the 9.5 magnitude. Even

in the course of the next half century, when the great Astrographic Catalogue may be completed, this will only show stars in general down to the twelfth magnitude, or even not quite so faint.

Therefore the only method of search is to take long exposure photographs of the region of the sky in which the new planet is expected to be found, and then after a suitable interval, probably of a few weeks, to photograph the region again. By comparing the very faintest points of light on similar plates it can then be determined whether one of these has moved slightly; if so, the moving body cannot be a star and may be the new planet. Any one who has seen a long exposed photographic plate of this region, which is in the Milky Way, with hundreds of thousands of stars on it, can imagine how laborious the search will be, even by photography. Visually, it would be practically impossible. Yet on any day the announcement of the new discovery may be made, and the limits of our solar system greatly extended.—Eric Doolittle, in *The Guide to Nature*, Feb. 1920.

Problems of Cosmogony and Stellar Dynamics, by J. H. Jeans, M. A., F. R. S. An essay to which the Adams Prize of the University of Cambridge for the year 1917 was adjudged. Cambridge University Press, 1919. New York, G. P. Putnam's Sons. Price, $6.50.

This is an exceedingly valuable book, written by a well-known English mathematician, one of those most fitted to undertake the solution of the difficult problems which he has attempted. The work is an extension of that by Laplace, Roche, Jacobi, Lord Kelvin, Poincaré, and Darwin, giving at the same time a résumé of what has been done before in the mathematical study of the evolution of configurations of gaseous masses, under the action of the forces resulting from rotation and gravitation. The mathematics of the book is not easy reading, but the author has interspersed the necessary array of equations with discussion which makes it possible to follow the results which he derives. The book is illustrated with five plates showing some of the most perfect photographs of planetary and spiral nebulæ which have been obtained at the Mount Wilson Observatory.

The author takes up first a general survey of the problem, then discusses in detail the Tidal Problem, the Rotational Problem, and the Double Star Problem, limiting the discussion first to masses of perfectly homogeneous and incompressible matter. He finds that from the tidal effect of the continued approach and ultimate recession of a secondary mass, there may result any finite number of detached masses from the primary. From the rotation of a single mass, rotating freely in space, the rotation increasing as the mass cools by radiation, the mass appears to divide into two bodies of unequal size. In the Double Star Problem the mass breaks up into a very great number of small masses.

He then takes up the general theory of the configurations of equilibrium of compressible masses, and finds in each of the models which he discusses, and independently of any particular model, a tendency of the mass to break up under increasing rotation and under the influence of tidal forces of sufficient intensity. Two methods of breaking up are found,—the one by fission, the other by ejection of streams of matter from a point or points on the boundary. Under certain

conditions the equatorial boundary of the rotating mass will become sharp-edged, and the angular velocity of the outer particles may be greater than that of the inner portions of the mass, so that matter in small particles may become detached all around the equator and thus form a ring. In case of disturbance by the approach of another body the ejection of particles might be concentrated at one point, or two opposite points, of the sharp edge, thus forming the one or two arms of a spiral nebula.

Many other problems are taken up by the author and treated in such a mathematical manner as to give his conclusions great weight.

The author hesitates to formulate general conclusions from the results of his investigations but he does give, in the last page and a half of the book, a statement of his views as to the probable manner of evolution of the stellar universe and our Solar System. This statement is so interesting that we give it in full in the following note.

Mr. Jeans' Views as to the Manner of Evolution of the Stellar and Solar Systems.—"It has not been part of our task to arrive at a conclusion; the time for arriving at conclusions in cosmogony has not yet come. Our object has rather been to consider different hypotheses in turn, pointing out and perhaps to some extent balancing the advantages and disadvantages of each, leaving it to future investigators, armed with more mathematical and observational knowledge than we at present possess, to pronounce a final decision.

"In so far as one conclusion has seemed to us more probable than another, it has been something of the following kind. Some hundreds of millions of years ago all the stars within our galactic universe formed a single mass of excessively tenuous gas in slow rotation. As imagined by Laplace, this mass contracted owing to loss of energy by radiation, and so increased its angular velocity until it assumed a lenticular shape similar to that of the figures shown on Plate II [Photographs of the spiral nebulæ Messier 50 and 101]. After this, further contraction was a sheer mathematical impossibility and the system had to expand. The mechanism of expansion was provided by matter being thrown off from the sharp edge of the lenticular figure, the lenticular center now forming the nucleus, and the thrown-off matter forming the arms, of a spiral nebula of the normal type. The long filaments of matter which constituted the arms, being gravitationally unstable, first formed into chains of condensations about nuclei, and ultimately formed detached masses of gas. With continued shrinkage, the temperature of these masses increased until they attained to incandescence and shone as luminous stars. At the same time their velocity of rotation increased until a large proportion of them broke up by fission into binary systems. The majority of the stars broke away from their neighbors and so formed a cluster of irregularly moving stars—our present galactic universe, in which the flattened shape of the original nebula may still be traced in the concentration about the galactic plane, while the original motion along the nebular arms still persists in the form of 'star-streaming'. In some cases a pair or small group of stars failed to get clear of one another's gravitational attractions and remain describing orbits about one another as wide binaries or multiple stars. The stars which were formed last, the present *B*-type stars, have been unusually immune from disturb-

ance by their neighbors, partly because they were born when adjacent stars had almost ceased to interfere with one another, partly because their exceptionally large mass minimised the effect of such interference as may have occurred; consequently they remain moving in the plane in which they were formed, many of them still constituting closely associated groups of stars—the moving star-clusters.

"At intervals it must have happened that two stars passed relatively near to one another in their motion through the universe. We conjecture that something like 300 million years ago our sun experienced an encounter of this kind, a larger star passing within a distance of about the sun's diameter from its surface. The effect of this, as we have seen, would be the ejection of a stream of gas towards the passing star. At this epoch the sun is supposed to have been dark and cold, its density being so low that its radius was perhaps comparable with the present radius of Neptune's orbit. The ejected stream of matter, becoming still colder by radiation, may have condensed into liquid near its ends and perhaps partially also near its middle. Such a jet of matter would be longitudinally unstable and would condense into detached nuclei which would ultimately form planets. The more liquid planets at the end of the chain would be those of smallest mass; the gaseous center would form the larger planets Jupiter and Saturn. Owing to the orbital velocity which had been communicated to these planets by the attraction of the passing star, they would not fall back into the sun but would describe elliptic orbits, passing fairly near to the sun's surface at their closest approach. As they passed relatively near to the sun, the same process as resulted in the formation of planets out of the sun, may have resulted in the formation of satellites out of the planets. It is not difficult to account for the systems of Jupiter and Saturn in this way, but the satellites of Neptune, Uranus, Mars, and the earth are less easy to explain. The system which interests us most nearly, namely our earth-moon system, is just the one about which it is most difficult to come to any definite conclusion. For the earth-moon system is exceptional in the system of the planets, just as the solar system to which it belongs appears to be exceptional, and for ought we know may be unique, in the system of the stars."

Navigation and Nautical Astronomy, prepared originally by Prof. J. H. C. Coffin of the U. S. Naval Academy; Eleventh edition, revised and enlarged by Elmer B. Collins, nautical expert, Navy Department. D. Van Nostrand Company, New York. Price $3.00, net.

A part of the original text and many of the examples in the previous edition have been eliminated as they are now obsolete. Several new chapters have been added. The chapter on the Sumner line has been changed and a chapter dealing with all cases met with in the New Navigation has been introduced. These changes should make the book an up-to-date one for the student of navigation.

Errata. Professor Pickering calls our attention to two misprints in his "Report on Mars, No. 22", in the February number of POPULAR ASTRONOMY:

On page 106, line 15, for "drawing" read "drawings".

On page 112, last line, for "258°.0" read "285°.0".

Polar Caps of Venus.—According to Mr. Edward M. Nelson, writing in the *English Mechanic*, polar caps were plainly visible on Venus last June in his 3-inch refractor, power 160. They are described as of intense whiteness, resembling that of the crater Aristarchus on the moon. A similar observation is reported from M. Flammarion's observatory at Juvisy, France. (*Scientific American*, Feb. 21, 1920.)

Lick Observatory Publications.—Vol. XIII of the Lick Observatory Publications, which has just come to hand, is a splendid volume, containing the results of work of which Dr. Campbell and his associates may justly be proud. The volume is devoted entirely to studies of the nebulæ and star clusters. We have just now only the time and space to give the titles of the Parts, leaving for a later issue a further review of the book.

Part I. Descriptions of 762 nebulæ and clusters photographed with the Crossley Reflector, by H. D. Curtis.

Part II. A study of occulting matter in the spiral nebulæ, by H. D. Curtis.

Part III. The planetary nebulæ, by H. D. Curtis.

Part IV. The spectroscopic velocities of the bright-line nebulæ, by W. W. Campbell and J. H. Moore.

Part V. The radial velocity of the Greater Magellanic Cloud, by R. E. Wilson.

Part VI. The wavelengths of the nebular lines and general observations of the spectra of gaseous nebulæ, by W. H. Wright.

"More than ever mixed."—The following little rhyme, taken from B. L. T.'s column in the San Francisco *Chronicle* for January 8, 1920, seems quite pat:

EINSTEIN.

Twinkle, twinkle, little star,
How I wonder where you are!
'Cording to the new complaint,
Where you seem to be, you ain't.

If your light waves have a kink,
What, on earth, are we to think?
Are you here, or are you there?
You might be 'most anywhere.

Viewed from our terrestrial ball,
Some things are not there at all.
What, for instance, is Orion?
And the Bear? Perhaps a lion!

Twinkle, twinkle, little star,
How I wonder where you are!
You are less than ever fixed;
I am more than ever mixed.

Elements and Ephemeris of Comas Solá's Asteroid.— From observations made at Northfield, Minnesota, on January 20, 24, and 30, I have computed the following elliptic elements and ephemeris for the asteroid discovered by Senor Comas Solá on January 13.

ELEMENTS.

Epoch 1920, January 25.5 G.M.T.

Mean anomaly	M =	337° 56′ 05″.3	
Longitude of node	☊ =	299 46 42	1920.0
Perihelion minus node	ω =	206 20 2	1920.0
Inclination	i =	20 25 30	1920.0
Log eccentricity	log e =	8.981681	
Log mean daily motion	log μ =	2.905148	
Log semi-major axis	log a =	0.429906	
Periodic time	P =	4.449 years	

EPHEMERIS.

Date 1920 G.M.T.		R.A. h m s	Dec. ° ′ ″	log Δ	log r
February	28.5	7 24 27.6	+17 32 39	0.22447	0.38791
March	3.5	7 23 37.9	17 08 57	0.23442	0.38770
	7.5	7 23 20.1	16 44 45	0.24469	0.38750
	11.5	7 23 32.8	16 21 34	0.25520	0.38732
	15.5	7 24 15.0	15 58 52	0.26585	0.38715
	19.5	7 25 25.4	15 36 32	0.27657	0.38699
	23.5	7 27 02.5	15 14 28	0.28729	0.38685
	27.5	7 29 04.2	+14 52 36	0.29796	0.38672

The residuals from these elements given above for the "Wilson and Gingrich" observation of January 27 are:

$$(O-C),\ \Delta\alpha = -0^s.6\ ,\quad \Delta\delta = +1''.2$$

R. A. ROSSITER.

Detroit Observatory February 26, 1920.

Practical Astronomy.—Another comet, says the Harvard Observatory, has been discovered gallivanting athwart the skies, by the Reverend Metcalf. This is the second comet caught on the wing by this illustrious sky-pilot; for which we duly thank him. But while roaming the ethereal blue, if Bro. Metcalf will draw a bead on Free-Trade's high cost of living and bring it to the earth, he will receive an immortal place in the galaxy of philanthropic discoverers. Or maybe he might coax down the cow that jumped over the moon and thus lower the cost of beefsteak. His name might aid in the enterprise. (*American Economist*, November 28, 1919.)